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APPENDIX

SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS

NAS10-8043

MARCH 1973

Prepared for

JOHN F. KENNEDY SPACE CENTER, NASA
KENNEDY SPACE CENTER, FLORIDA

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TRW SYSTEMS GROUP

FOREWORD

This document is submitted in accordance with the requirements stated in Section 7.0 of the Statement of Work for KSC Contract NAS10-8043.

GLOSSARY

AFETR	Air Force Eastern Test Range
ARPA	Advanced Research Projects Agency
C&D	Controls and Displays
C&W	Caution and Warning
CARR	Customer Acceptance Readiness Review
CDC	Control Data Corporation
CDR	Critical Design Review
CPFF	Cost Plus Fixed Fee
CRT	Cathode Ray Tube
CSS	Central Support System
CF	Cubic Feet
CV-990	Convair 990 Aircraft
DCCU	Digital Control Combiner Unit
DMS	Data Management System
DOD	Department of Defense
ECLSS	Environmental Control and Life Support System
ECP	Engineering Change Proposal
EEE	Electronic, Electrical, Electromechanical
EMI	Electromagnetic Interference
ETR	Eastern Test Range
FFG	Flexible Format Generator
FSS	Flight Scheduling Subsystem
FMEA	Failure Mode and Effects Analysis
GAEC	Grumman Aircraft and Engineering Corporation
GSE	Ground Support Equipment
GSS	Ground Support Systems
Hz	Hertz
ICD	Interface Control Drawing
IMS	Information Management Subsystem
I/O	Input/Output
IR	Infrared
IST	Integrated Systems Test
KSC	Kennedy Space Center
KW	Kilowatt
LaRC	Langley Research Center
LiOH	Lithium Hydroxide

LPS	Launch Processing System
LSS	Logistics Support System
MDAC-E	McDonnell Douglas Astronautics Company East
MDAC-W	McDonnell Douglas Astronautics Company West
MDAS	Mission Design and Analysis Subsystem
MCF	Maintenance and Checkout Facility
MMC	Martin Marietta Corporation
ML	Mobile Launcher
MPAD	Mission Planning and Analysis Division
MSC	Manned Spacecraft Center
msec	Millisecond
MSOB	Manned Spacecraft Operations Building
MSS	Management Support System
MTF	Maintenance and Test Facility
NOAA	National Oceanographic and Atmospheric Administration
NR	North American Rockwell Corporation
O&M	Operations and Maintenance
ONR	Office of Naval Research
OSS	Operations Support System
PCS	Payload Checkout System
PDD	Payload Description Document
PDR	Preliminary Design Review
PI	Principal Investigator
PIM	Payload Integration Mockup
PRD	Program Requirements Document
PSIA	Pounds per square inch absolute
QRIA	Quick-Reaction Integration Activity
QRSL	Quick-Reaction Sortie Lab
RAM	Research and Applications Module
RAU	Remote Acquisition Unit
RCA	Radio Corporation of America
R&D	Research and Development
RF	Radio Frequency
R&I	Receiving and Inspection
SAMSO	Space and Missile Systems Organizatoon

SCN	Specification Change Notice
SF	Square Feet
SID	Shuttle Integration Device
SL	Sortie Lab
SMEAT	Skylab Medical Equipment Altitude Test
SMVO	Medium Launch Vehicle Directorate
SOAR	Shuttle Orbital Applications and Requirements
SPO	Scout Project Office
SRM	Solid Rocket Motor
TELTA	TEthered Lighter Than Air
TLM	Telemetry
UCS	Utilities Control System
ULO	Unmanned Launch Operations
VAB	Vertical Assembly Building
VCLS	Vehicle Checkout and Launch System
VCM	Vehicle Countdown Manual
VMS	Vehicle Maintenance System
VOP	Vehicle Operating Plan

TABLE OF CONTENTS

VOLUME I

		Page
SECTION 1 - INTRODUCTION		1-1
1.1	QUICK-REACTION EXPERIMENT CONCEPTS	1-1
1.1.1	Introduction	1-1
1.1.2	General	1-1
1.1.3	Time	1-2
1.1.4	Cost	1-3
1.1.5	Simplicity	1-3
1.1.6	Documentation	1-4
1.1.7	Summary	1-4
SECTION 2 - REVIEW OF OTHER PAYLOAD PROGRAMS		1-6
2.1	WALLOPS ISLAND SOUNDING ROCKET PROGRAM	1-6
2.1.1	General Discussion and Program Features	1-6
2.1.2	Scout Payload Integration Program Management	1-6
2.1.3	Documentation	1-7
2.2	MIGHTY MOUSE PROGRAM	1-9
2.2.1	Program Features	1-9
2.2.2	Organization	1-10
2.2.3	Documentation	1-11
2.3	CV-990 PROGRAM	1-12
2.3.1	Program Description	1-12
2.3.2	Management	1-14
2.3.3	Documentation	1-14
2.4	TELTA BALLOON PROGRAM	1-15
2.4.1	General Discussion	1-15
2.5	DELTA/CENTAUR PROGRAM	1-17
2.5.1	Program Features	1-17
2.5.2	Management and Organizational Interface	1-17
2.5.3	KSC/ULO Involvement	1-20
2.5.4	Launch Operations	1-20
2.5.5	Documentation	1-21
2.5.6	Program Cycle	1-21
2.6	APOLLO/SKYLAB PAYLOAD PROGRAMS	1-24
2.6.1	Apollo Payload Program	1-24
2.6.1.1	Apollo Program Objectives and Principal Features	1-24
2.6.1.2	Organizational and Equipment Interfaces	1-24
2.6.1.3	Documentation Requirements and Management System	1-25
2.6.2	Skylab Payload Program	1-25
2.6.2.1	Program Objectives and Principal Features	1-25
2.6.2.2	Organizational and Experiment Interfaces	1-27
2.6.2.3	Documentation Requirements and Management Systems	1-27

		Page
SECTION 3 - SURVEY, ASSEMBLE AND ORGANIZE PAYLOAD DATA		1-35
3.1	SOURCES	1-35
3.2	SORTIE LAB CAPABILITIES	1-35
3.2.1	General Mission Characteristics	1-35
3.2.2	Crew	1-35
3.2.3	Sortie Lab Facilities	1-36
3.2.4	Payload Weight	1-36
3.2.5	Electrical Power	1-36
3.2.6	Environmental Control	1-36
3.2.7	Data Acquisition	1-36
3.2.8	Data Storage and Processing	1-37
3.2.9	Data Sequencing and Control	1-37
3.2.10	Communications	1-38
3.3	SHUTTLE ORBITER CAPABILITIES	1-38
3.4	FUTURE CHANGES IN ORBITER AND SORTIE LAB CAPABILITIES	1-38
SECTION 4 - GROUND OPERATIONS REQUIREMENTS		1-43
4.1	INTRODUCTION	1-43
4.2	LAUNCH SITE GROUND OPERATIONS	1-43
4.2.1	Experiment Ground Operations	1-47
4.2.1.1	Laboratory Preparation	1-53
4.2.1.2	Handling and Transportation	1-53
4.2.1.3	Receiving and Inspection	1-54
4.2.1.4	Pretest, Setup and Calibration	1-54
4.2.1.5	Experiment Hardware Functional Checkout	1-55
4.2.1.6	Experiment Sensor Calibration	1-57
4.2.1.7	Move to Quick-Reaction Sortie Lab Area	1-57
4.2.1.8	Postflight Experiment Operations	1-57
4.2.2	Quick-Reaction Sortie Lab Ground Operations	1-58
4.2.2.1	Quick-Reaction Sortie Laboratory Description	1-58
4.2.2.2	Quick-Reaction Sortie Functional Flow	1-60
4.2.2.3	Payload/Shuttle Integration Tests	1-65
4.3	SHUTTLE GROUND OPERATIONS	1-65
SECTION 5 - INTERFACE ASSESSMENT		1-71
5.1	ASSESSMENT OF THE NEED FOR A PAYLOAD INTEGRATION MOCKUP AND A SHUTTLE INTEGRATION DEVICE	1-71
5.2	PIM ANALYSIS	1-72
5.3	SID ANALYSIS	1-72
SECTION 6 - OTHER REQUIREMENTS AND FACTORS		1-75
6.1	FACTORS RELATED TO FOREIGN, DOD, AND COMMERCIAL PAYLOADS	1-75
6.1.1	Foreign	1-75
6.1.1.1	Program Management	1-75
6.1.1.2	Engineering Competence	1-76

		Page
6.1.1.3	Product Integrity	1-76
6.1.1.4	Testing	1-76
6.1.1.5	Net Results	1-76
6.1.1.6	Effect on Launch Site Integration	1-76
6.1.1.7	Summary	1-77
6.1.2	DOD	1-77
6.1.3	Commercial	1-78

VOLUME II

SECTION 1 - INTRODUCTION		2-1
SECTION 2 - ILLUSTRATIVE EXAMPLE		2-2
2.1	INTRODUCTION	2-2
2.2	INSTRUMENT DESIGN	2-2
2.3	OPTICAL	2-2
2.4	MECHANICAL	2-4
2.5	ELECTRONIC	2-5
2.6	ON-LINE PROCESSING	2-7
2.7	FLIGHT PERFORMANCE	2-10
SECTION 3 - QUICK-REACTION INTEGRATION CONCEPT		2-11
3.1	OVERVIEW	2-11
3.2	KSC MODEL SHOP	2-11
3.3	LAUNCH PROCESSING SYSTEM	2-12
3.3.1	Functional Definition	2-12
3.4	VEHICLE MANAGEMENT AND MISSION PLANNING SYSTEM	2-16
3.4.1	VMMPS Development at MSC	2-16
3.4.2	VMMPS Planning Functions	2-17
3.4.3	VMMPS Development Approach	2-20

VOLUME III

SECTION 1 - INTRODUCTION		3-1
SECTION 2 - USER'S SURVEY		3-2
SECTION 3 - QUICK-REACTION USER'S GUIDE		3-4
SECTION 4 - LAUNCH SITE IMPACT		3-7
4.1	QR SORTIE LAB ASSEMBLY, TEST AND CHECKOUT AREA	3-7
4.2	EXPERIMENT LABORATORY AREA	3-8
4.3	ENVIRONMENTAL QUALIFICATION LAB	3-9
4.4	SUMMARY OF FACILITY REQUIREMENTS	3-9
4.5	GROUND SUPPORT EQUIPMENT REQUIREMENTS	3-9
SECTION 5 - ORGANIZATION AND MANPOWER ANALYSIS		3-14
SECTION 6 - SENSITIVITY ANALYSIS		3-20
SECTION 7 - LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS		3-23

LIST OF FIGURES AND TABLES

Figure		Page
1-1	Payload Integration Program Management Organization	1-7
1-2	Mighty Mouse Program Organizational Interfaces	1-10
1-3	CV-990 Experiment Selection	1-13
1-4	KSC/ULO Organization	1-19
1-5	Ground Operations Requirements Functional Flow Diagram	1-45
1-6	Group A Experiment Hardware Timeline	1-48
1-7	Group A Type III Experiment Hardware Timeline	1-48
1-8	Group B Experiment Hadrware Timeline	1-49
1-9	Group C Experiment Hardware Timeline	1-49
1-10	Group D Experiment Hardware Timeline	1-50
1-11	Group E Experiment Hardware Timeline	1-50
1-12	Group F Experiment Hardware Timeline	1-51
1-13	Group F Experiment Hardware Timeline at Pad	1-51
1-14	Environmental Qualification Testing Timeline	1-52
1-15	Quick-Reaction Sortie Laboratory	1-60
1-16	Quick-Reaction Sortie Lab Timeline	1-61
1-17	KSC Space Shuttle Planning Chart	1-69
2-1	Aeropol Electronics System Block Diagram	2-6
2-2	Aeropol Program Flow Chart	2-9
2-3	Launch Processing System	2-14
2-4	Vehicle Management and Mission Planning System	2-18
2-5	VMMPS Element Functions	2-18
3-1	QRSL Assembly, Test, and Checkout Area	3-7
3-2	QRIA Time-Based Functional Flow Diagram	3-21
3-3	Location/Responsibility Alternatives Analysis	3-25

Table		Page
1-1	KSC/ULO Involvement	1-20
1-2	Documentation Interfaces	1-22
1-3	Baseline Experiment Hardware	1-41
1-4	Experiment Categories	1-44
2-1	Filter Characteristics	2-4
2-2	LPS Hardware and Software Subsystems	2-15
3-1	Estimated Costs of Facility Requirements	3-11
3-2	Estimated Costs of GSE Requirements	3-12
3-3	Standard Sortie Lab Manpower Estimate	3-14
3-4	QRIA Autonomous Organization Manpower	3-16
3-5	Technicians for QRSL	3-17
3-6	Manpower Analysis	3-18

SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS

Detailed Technical Report

Volume I

Appendix

SECTION 1 - INTRODUCTION

1.1 QUICK-REACTION EXPERIMENT CONCEPTS

1.1.1 Introduction

The Quick-Reaction experiment concept for the Shuttle era has been tossed around for some time. Unfortunately, there is no common understanding or agreement among those interested as to what it really means, except in the broadest terms. The misunderstanding and disagreements appear when specific ideas or definitions are employed in defining Quick-Reaction.

To effectively proceed with this study it is necessary that Quick-Reaction be as explicitly defined as possible. This is not to imply that other definitions or ideas of Quick-Reaction are not valid, but only that one had to be used as a baseline from which to proceed.

Quick-Reaction cannot easily be defined in the dictionary sense. Rather, the concept of Quick-Reaction consists of a set of other concepts and/or definitions which, when taken collectively, constitute a definition or a description of Quick-Reaction.

In what follows, the individual elements used in developing the Quick-Reaction concept description are discussed along with alternative definitions or descriptions of each element. That definition or element description finally chosen as part of the Quick-Reaction description is also indicated.

The sources of the elements considered, and other thoughts and ideas of the Quick-Reaction concept, include the Martin Company report (NAS10-7685), the statement of work for this study, the TRW proposal, conversations with both KSC and TRW personnel and original ideas developed by the study team. Included are refinements developed by the study team as Phase 1 of this study progressed. Other refinements will doubtlessly occur in succeeding phases of the study.

1.1.2 General

The word "Quick" in Quick-Reaction implies some short increment of time. For the purposes of this study, this time refers not only to experiment integration time

1.1.2 General (Cont.)

but also is concerned with the length of time of user (experimenter, PI, scientist, etc.) involvement.

Eliminated for consideration as a definition of Quick-Reaction for this study is the rapid response type of mission for observation of unexpected catastrophic events or unpredicted targets of scientific opportunity. While this is a valid type of Quick-Reaction concept, it is outside the scope of the present study as far as detailed analysis is concerned.

1.1.3 Time

The selection of time span to assign to the Quick-Reaction concept is difficult and, in some respects, arbitrary. The end point of the span is fairly obvious, namely, data receipt, i.e., when the experimenter receives his data from the Shuttle mission. It is the initial point that is subject to assignment. Bearing in mind that one of the objectives is to widen the user market and increase user participation and involvement leads to the idea that whatever time span is chosen, it should take into consideration the user. Among the possibilities considered were:

- user concept to data receipt
- proposal to data receipt
- AFO to data receipt
- hardware arrival at integration site to data receipt

The last item is the only one over which the launch/integration site could have direct control since the majority of payloads will be developed under the direction of NASA or government agencies other than at the launch site. The integration site then will have little control over the developmental span time. What the integration site can control is the integration time and hence make it possible for total span time to be relatively short.

Span times for other payload programs run anywhere from 8 to 12 months (sounding rocket, CV-990, balloon programs) and as high as 24 to 60 months on the larger unmanned and manned programs, including hardware development. Based on this historical experience and the objectives of this study, a possible span time of 9 to 12 months is a reasonable target.

In summary, the "time" elements for Quick-Reaction for purposes of this study are:

- a short launch site integration and checkout time (6 to 12 weeks)

1.1.3 Time (Cont.)

- encourage an overall short concept to data span time by reacting and performing quickly in those areas over which the launch site has control - the launch/integration site imposes no impediments or arbitrary time consuming requirements in the flow.

1.1.4 Cost

Low cost experimentation is a universally accepted goal of the Shuttle era space program. For the Quick-Reaction concept this element means two things, viz., low operation cost to the user and low Shuttle program and mission costs

With respect to the user and for the same reason cited earlier, the launch/integration site will have little direct control over developmental costs. For this fraction of the user cost, the integration site can only encourage low cost development and develop integration philosophies and requirements which will not cause undue cost escalations during development due to their imposition.

For that remaining fraction of user costs and other program and mission costs, the launch/integration site should have a degree of control and positive effect. in several ways. These include:

- the use of low cost operations in integrating Quick-Reaction experiments
- use of cost effective expertise in checkout and calibration, i.e., the user
- reasonable size and weight restrictions which in turn reduce handling and transportation times and costs
- reasonable restrictions on hardware design to minimize requirements for specialized and unique procedures and/or ground equipment during the checkout, test and integration phases
- encourage the use of off-the-shelf and standard components, thus reducing the hardware cost per pound as well as the test and checkout of new components.

In summary the "cost" elements of the Quick-Reaction definition for this study are:

- encourage low cost development
- low cost checkout, test and integration at the launch site
- high user involvement

1.1.5 Simplicity

Simplicity, for Quick-Reaction experiments, need not imply that the scientific phenomena or idea is necessarily simple or, for that matter, that the hardware itself

1.1.5 Simplicity (Cont.)

is simple. What is implied is that the hardware be reasonably straightforward and simple to integrate to the experiment carrier and that it does not require specialized and unique ground support equipment for checkout and/or integration at the launch/ integration site.

It may be complex with respect to its internal operation. However, it should be simple to operate and maintain, not requiring excessive crew training and complex operational procedures.

In summary, "simplicity" for the Quick-Reaction experiments implies:

- relatively simple to checkout and integrate at the launch site
- relatively simple to operate
- ease of maintenance

1.1.6 Documentation

• The formal documentation requirements relating to launch site integration, test and checkout of the Quick-Reaction experiments should be minimal. Maximum use should be made of informal coordination and verbal communications. As cited earlier, the launch/integration site will have little control over the development process, however even here the thrust should be the encouragement of minimal formal documentation requirements and the use of standard handbooks and guides.

In summary, "documentation" goals for Quick-Reaction experiments are:

- minimal documentation requirements for the launch/integration site
- maximum use of verbal and informal communications
- use of standard handbooks and guides
- encourage minimal documentation requirements for the overall program

1.1.7 Summary

The principal elements used in developing the definition/description of Quick-Reaction as used in this study have been Time, Cost, Simplicity, and Documentation. The meanings of each of these elements as applied to Quick-Reaction have been discussed and stated. These elements and their definitions as stated, when taken collectively, describe what we mean by Quick-Reaction in this study.

The underlying key in all of this, however, is the user. We must attempt to give the user what he wants and to use him effectively. This includes providing

1.1.7 Summary (Cont.)

him with assistance and facilities at the launch site and removing or reducing unnecessary requirements and impediments.

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"Shuttle Launch Site Operational Concepts for Certain Sortie Missions", Technical Proposal, TRW, 15 May 1972

"Implementation of Research and Applications Payloads at the Shuttle Launch Site", Detailed Technical Report, Volume III, Contract No. NAS10-7685, Martin Marietta Corp, March 1972

SECTION 2 - REVIEW OF OTHER PAYLOAD PROGRAMS

2.1 WALLOPS ISLAND SOUNDING ROCKET PROGRAM

2.1.1 General Discussion and Program Features

The Wallops Island Sounding Rocket Program is a user oriented multidisciplinary program providing space sciences research opportunities to the scientific community.

The program philosophy requires a high level of PI involvement and responsibility. This includes payload management, development, data analysis and mission objectives. Wallops Island, in addition to providing launch and range services and facilities, provides payload checkout facilities and payload vehicle integration as well as trajectory analysis support to the PI.

Operationally there is a single point responsibility vested in the program manager. He arbitrates disagreements and has authority to make real-time decisions. Prior to launch the program manager and the PI establish a minimum success criteria to preclude the compromise of scientific data and to ensure last minute indecision during the launch situation.

The documentation requirements imposed on the PI are minimal, consisting primarily of a proposal and a requirements document spelling out payload requirements, mission objectives, etc.

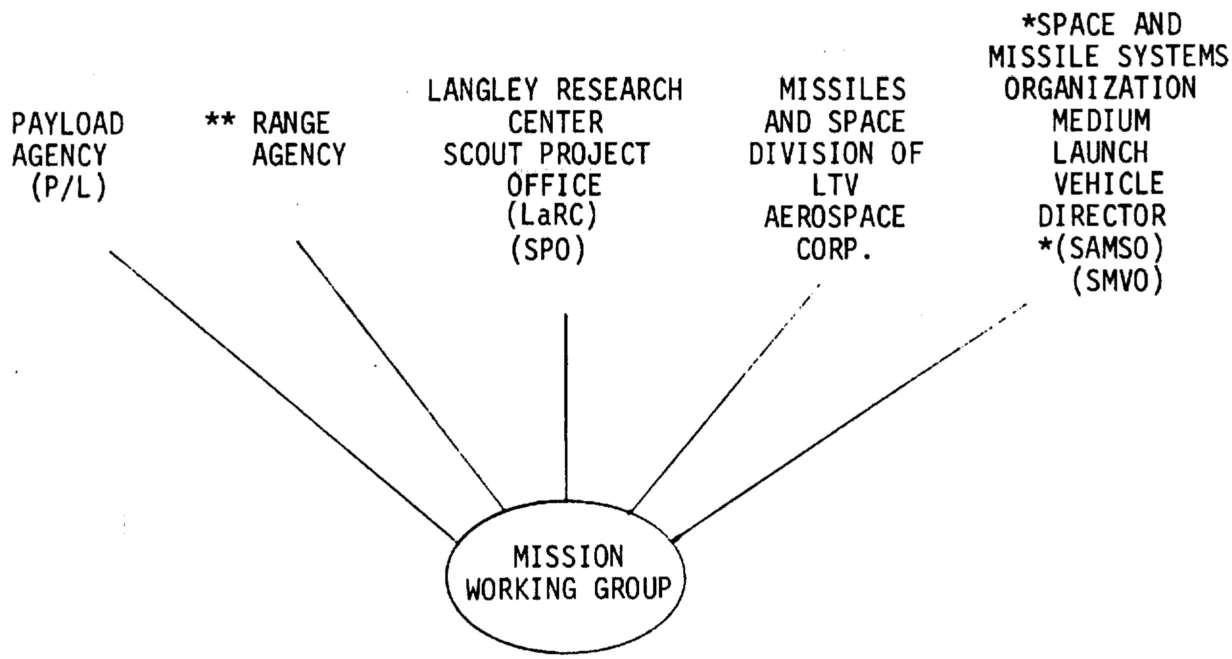
The project span time is also rather short, typically on the order of 9 to 12 months.

2.1.2 Scout Payload Integration Program Management

Since the area of general payload-to-vehicle integration and payload coordination involves a number of different agencies, a submanagement organization is formed to coordinate the entire payload-to-vehicle integration program. This organization is called the Mission Working Group. Specifically this group is responsible for the direction of all documentation efforts, the physical integration program, the operational integration program and is, in general, charged with mission responsibility at the working level. Figure 1-1 schematically presents the relationship of the Mission Working Group to its parent agencies. The basic

2.1.2 Scout Payload Integration Program Management (Cont.)

group is formed of one qualified person from each prime agency connected with the program. It is formed by LaRC or SMVO upon official assignment of the payload to Scout. The policies that govern the operation of the Mission Working Group are delineated in Section 5 of the Scout User's Manual.



* For all Department of Defense (DOD) Vehicles

** Range Representation shown above is invited at an appropriate time prior to launch.

FIGURE 1-1. PAYLOAD INTEGRATION PROGRAM MANAGEMENT ORGANIZATION

2.1.3 Documentation

A minimal documentation philosophy has been implemented for the Wallops Island Sounding Rocket Program. The principal documentation requirements for a typical project (Scout), excluding the PI proposal and associated correspondence, are:

- A Payload Description Document (PDD) prepared by the PI following a standard format provided by the Program Office. This document provides the Program Office with necessary Administrative Data, 2.1.3 Documentation (Cont.)

General Information on the mission objectives, constraints, and requirements, Payload Technical Data, Range Support Requirements, and Operational Information.

- A Vehicle Operations Plan (VOP) is prepared by the Wallops Island Operations Engineering personnel at least 21 days prior to launch. This document contains detailed descriptions for general test information, mission description, vehicle description, control and operation, support requirements, and data requirements.
- A Vehicle Countdown Manual (VCM) is prepared by the Wallops Island Systems Engineering Personnel at least 15 days prior to launch. This document contains detailed procedures for systems checkout, launcher elevation, fueling, arming and launch.
- User's Manuals provided by the Wallops Island Program Office contain information for the user's detailing requirements, constraints, and facilities available. This document is updated as required.

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"Flight Plan for Aerobee Rocket", NASA 4.171 UG, GSFC, 22 April 1966

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2.2 MIGHTY MOUSE PROGRAM

2.2.1 Program Features

The Mighty Mouse Program is a lightning research program operated by KSC. There are several features of this program which are unique and enhance its Quick-Reaction capability. These features are summarized in the succeeding paragraphs.

- The program is narrow in scope in that it has only one objective, i.e., lightning research. This allows for a well defined streamlined operation, maximum hardware commonality, and standard operating procedures for the involved personnel.
- The standard payloads are furnished and calibrated by a single PI remote from the launch site. There is no PI involvement at the launch site.
- The standard launch vehicles are furnished by the Office of Naval Research (ONR) on request by NASA.
- The reaction time for this program is extremely short. Procedures allow for a maximum 24 hour alert for a possible launch the following day. This alert is provided by the KSC and AFETR meterological staffs. However, this is not always available and the time from crew alert and dispatch to launch can nominally be as little as 2 hours and has been as short as 55 minutes. Sufficient launch vehicles and payloads are checked out in advance for a minimum of two days' operations. A typical operation involves approximately 50 personnel including two launch crews of 5 men each.
- Well defined operational procedures have been developed which allow for real-time decisions providing a high degree of flexibility.

2.2.2 Organization

The organizational interfaces involved in this simple program are shown in Figure 1-2.

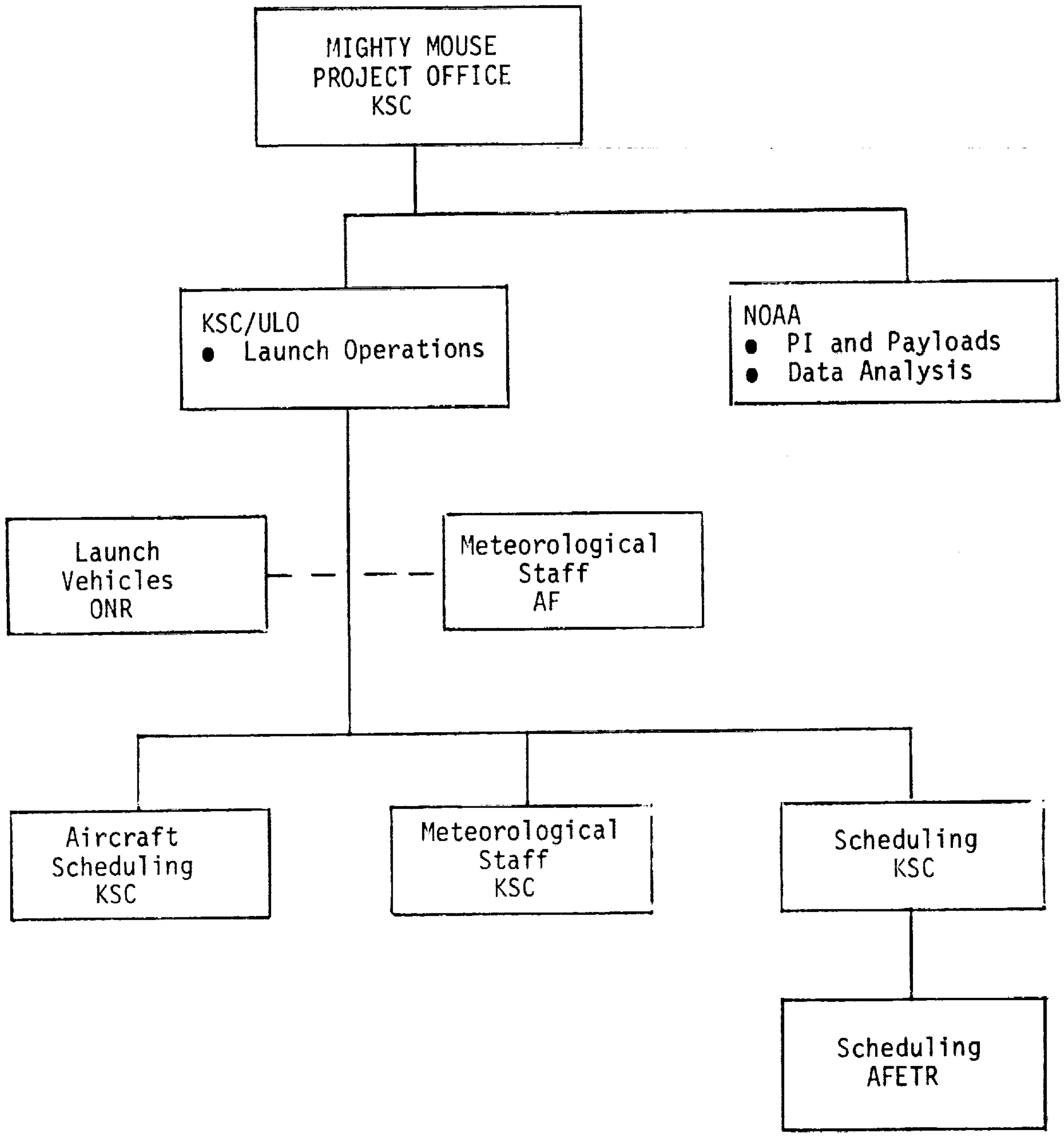

FIGURE 1-2. MIGHTY MOUSE PROGRAM ORGANIZATIONAL INTERFACES

2.2.3 Documentation

The documentation system for this program is particularly clean and streamlined, consisting primarily of requirements, specifications and procedures documents updated as required. In its day-to-day operations a high use of verbal communications is used rather than formal requests and/or written communications. The basic documentation is listed and described below.

- Requirements Document

  This document details the KSC requirements, specifies the standard operating procedures, and spells out the data disposition procedures. It is updated as required.

- Operational Requirements Document

  This document specifies the AFETR requirements and procedures. It is updated as required.

- Official Drawings and Specifications

  These documents provide the detailed specifications for all Mighty Mouse Program hardware. They are updated and approved as required.

- PI Reports

  These are provided at random intervals by the PI, usually upon verbal request by the program manager.

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Private Communication, F. C. Drury, LL-OPN-1, Launch Operations Director

2.3 CV-990 PROGRAM

2.3.1 Program Description

The CV-990 Program operates at the NASA Ames Research Center, Moffett Field, California using a Convair Model 990 jet aircraft that has been converted from passenger service to service as a flying test bed for experimenters. This program provides for research into two areas: aeronautics and space sciences. The aeronautics experiments are limited to those that are related to aircraft performance. The space sciences experiments utilize the CV-990 aircraft as an airborne platform. A typical mission involves approximately 12 experiments and their selection is based on whether their objectives are complementary and the compatibility of their flight requirements.

Very little formal documentation is used in this program. An investigator desiring to fly an experiment on the CV-990 first submits a proposal to NASA for review and approval. If he wants NASA financial support a cost proposal must be included. Approximately three months is required for a five man experiment steering committee located at NASA headquarters to approve and select an experiment. Typically, approximately seven months is required to design and fabricate the experiment hardware. For safety and structural reasons the investigator must submit stress analysis calculations of the experiment mounting structure to NASA/Ames for approval. Two months is then required for integration, installation in the aircraft and actual flight. Thus, approximately one year is required to complete an experiment from the time it is approved until completion of the flight. The experiment selection flow is shown in Figure 1-3.

The experiments can be flown on the CV-990 program for about $35 a pound. The reason for this economy is attributable to several things. First, the program requires the total personal involvement of the investigator. He fabricates the experiment and operates and maintains it during flight, manages the project, processes the data, and reports on the results. In short, if the experiment is successful, it is because the investigator performed his many functions properly. There are no formal reports or documentation of the experiment data required from the investigator by NASA. The only documentation on the experiment results are informal entries into the mission manager's and the investigator's laboratory type notebooks.

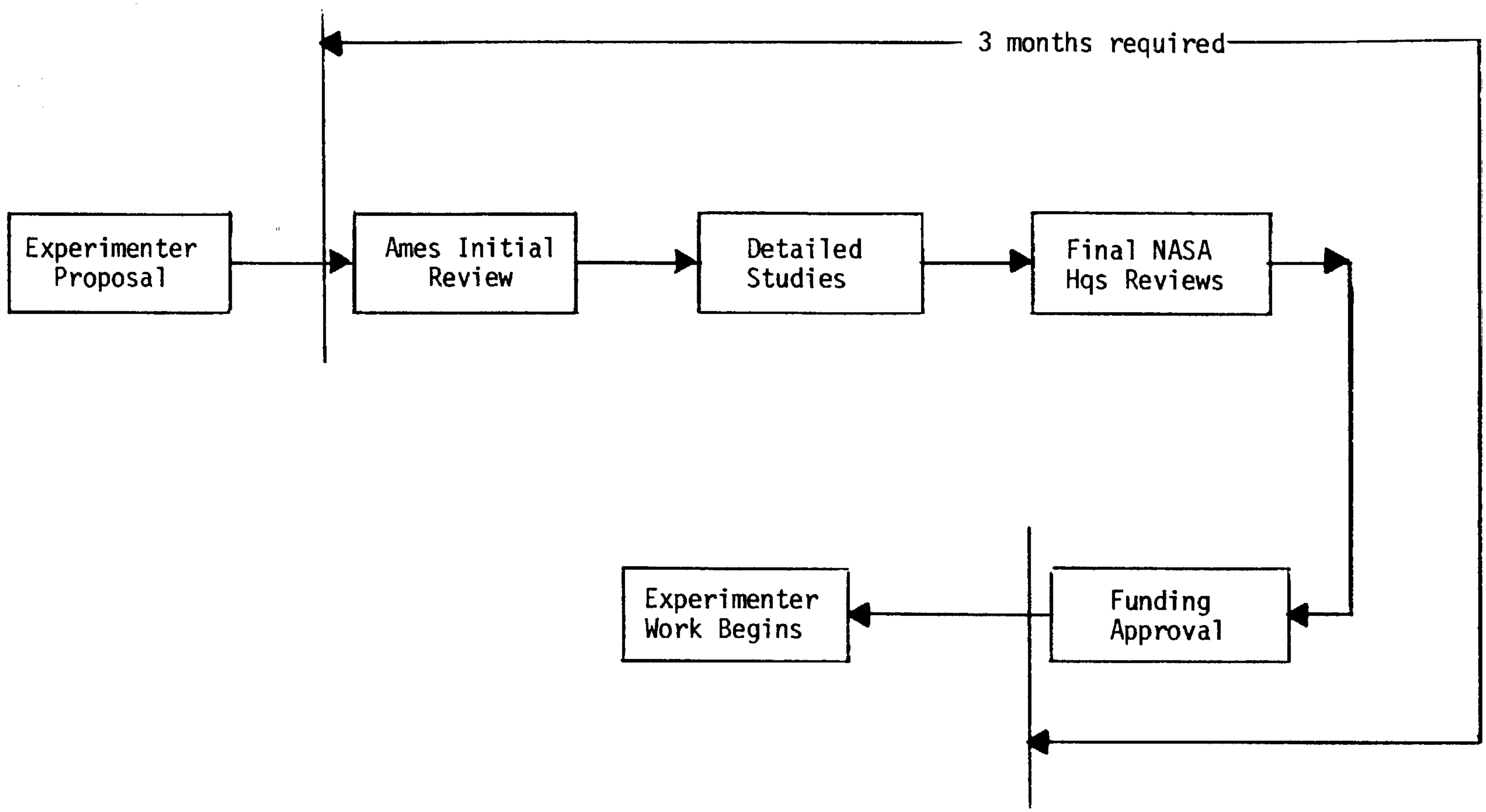

FIGURE 1-3. CV-990 EXPERIMENT SELECTION

2.3.2 Management

- Program managed by NASA/Ames, by approximately 15 people *excluding* aircraft maintenance and flight crew personnel.
- Mission approval and experiment selection by five man steering committee at NASA/Headquarters - requires up to three months.
- Organizational interfaces:

  NASA Ames Research Center, Code SS

  NASA Headquarters, Codes SG, RAD, SRR, I, Y
- Minimum lead time of six months required prior to first use of aircraft for average experiment. Longer time is required for complex or multi-experiment efforts.

2.3.3 Documentation

- Experiment proposals, from all sources:

  3 copies of (A) or (S) to NASA, Washington, Code RAD or SG

  2 copies to NASA Ames Airborne Science Office, Code SS
- Experiment proposals, from all U.S. sources, except NASA:

  10 copies to Office of University Affairs, Code Y, NASA, Washington

  Plus the above five copies
- Experiment proposals, from foreign sources:

  10 copies to Office of International Affairs, Code I, NASA, Washington

  Plus the above five copies
- Cost Proposal - required if NASA financial support is desired - does not include flight or logistics costs.
- No formal reports or data distribution, only informal entries into mission manager's and investigator's laboratory type notebooks.

Bibliography

"NASA CV-990 Airborne Laboratory Experimenters' Handbook", NASA, November 1970

"Potential Reductions in Cost and Response Time for Shuttleborn Space Experiments", Bader and Farlow, no date

"Implementation of Research and Applications Payloads at the Shuttle Launch Site", Detailed Technical Report, Volume I, Contract No. NAS10-7685, Martin Marietta Corp, November 1971

2.4 TELTA BALLOON PROGRAM

2.4.1 General Discussion

The TELTA (TEthered, Lighter Than Air) balloon program is operated at the Cape Kennedy Air Force Station (CKAFS) for the Advanced Research Projects Agency (ARPA) of the Department of Defense (DOD) on a cost plus fixed fee (CPFF) contract. There are two balloon sites at Cape Kennedy; however, it is apparently very simple to relocate these sites almost anywhere. At present (summer 1972) one balloon and crew is operating in Key West, Florida carrying Navy payloads. Recently another balloon and crew was located in Norfolk, Virginia, also performing work for the Navy.

RCA is the contractor for the balloon at Cape Kennedy and, at present, Westinghouse is the payload contractor for several classified payloads. RCA performs the function of integrating the payload and the flight vehicle (balloon). This is a relatively simple task that consists of attaching the payload to the balloon, connecting power cable(s) and TLM cable(s) if required. For the two site operation, RCA employs a total of 30 people including management, engineering, maintenance, and administrative personnel. Westinghouse has three to five people for the payload work, depending on the payload complexity.

This is still an R&D program rather than an operational one, because the balloon itself is still under test in an effort to develop ways and means to improve it. Several of the TLM channels are utilized to monitor the "state of health" of the balloon and to acquire data from the various strain gages and transducers associated with the balloon research.

In addition to the numerous classified payloads, RCA is also flying other payloads when time permits. Some of these, if they are simple and small, are flown piggyback with other, larger payloads. The balloon can carry payloads that weigh as much as 1,000 pounds. Its maximum attitude is 10,000 feet and is a function of payload weight. A new balloon will be available soon that will go to 12,000 feet. RCA is presently flying an atmospheric conductivity experiment for NOAA as a part of the experimental lightning research program. Another experiment involves flying transponders that permit the Navy to perform radar calibrations.

2.4.1 General Discussion (Cont.)

There are 36 channels of TLM available on the balloon. Approximately six of these are used for balloon R&D data. The others are available for experiment data requirements. Five KW of power is available, most of it for the experimenter. The balloon requires a small amount of power for a helium vent valve in the event the balloon escapes its tether. A 10 channel command system is also available. Nine channels are available to the experimenter.

Very little formal documentation is used in this program. The program is managed by a local ARPA office located at Patrick AFB. Requests for flight time are directed to this office either directly by the experimenters or from the Washington ARPA office. Verbal approval is given and verbal instructions are given to RCA to fly the experiment either as a separate payload or piggyback, if appropriate. The time interval from ARPA approval to flight is very short if the experiment is constructed and ready to go on board. For very simple experiments this time interval is on the order of two days. More complicated or larger payloads require more time. Some of the larger payloads require informal RCA time and cost estimates if additional manpower or materials are needed above that normally provided for in the contract.

Bibliography

Telecon, Robert Murkshe, RCA

2.5 DELTA/CENTAUR PROGRAM

This section documents the review of the Centaur and Delta Programs with respect to their applicability to the Quick-Reaction Payload concept. It covers both Centaur and Delta Programs as a single payload program because they are very similar in overall operation.

2.5.1 Program Features

The significant characteristics of the Centaur and Delta Programs with respect to payloads are summarized as follows:

- The launch vehicles for these programs can be considered as approaching an operational status in the sense that the checkout GSE, procedures, launch crews, and program interfaces are well established through several years of operation. This characteristic does not hold for the Delta to quite the same degree as Centaur because of the upgrading modifications to the Delta launch vehicle. Nevertheless, the overall launch operations of these vehicles with respect to payloads are pretty much standardized.

- These programs are subjected to a formal documentation loop which requires coordination, review cycles, and signatory sign-offs. This documentation loop involves other NASA centers and government agencies in that many of these programs encompass two NASA Headquarters' program offices and two or more NASA management centers.

- The program cycle for payloads involving the Delta/Centaur is extensive and generally runs from three to five years.

- KSC's involvement in these programs is a supportive role to the NASA Spacecraft Management Centers. KSC has no responsibility for payload/experiment checkout except where that testing interfaces with the launch vehicle.

- The payloads with which these programs have been involved have been end-item oriented, i.e., the spacecraft and the experiments on board are mission dependent and therefore influence mission success criteria. Also, these payloads have been large in size and require large supporting facilities. Consequently, entire buildings, e.g., AM, AO, etc., must be dedicated to these payloads which impose maintenance and scheduling requirements on KSC for several years in advance.

2.5.2 Management and Organizational Interfaces

The lead center concept is used on payloads involving the Delta and Centaur

2.5.2 Management and Organizational Interfaces (Cont.)

Programs. The responsibilities and organizational structures are established by Headquarters directives and implemented through interface agreements between the various NASA centers and other government agencies.

The Spacecraft Management Center has cognizance over any experimenters or principal investigators (PI's) on a particular spacecraft. The documentation flow is between these groups. During the launch site stay time, the Spacecraft Management Center has a project representative or manager at the launch site. In addition, the PI's and the spacecraft contractors' personnel, who perform checkout and servicing, are also at the launch site. KSC/ULO has no responsibility for payload/experiment checkout except where that testing interfaces with the launch vehicle, nor does KSC/ULO have any formal interface with the PI's. The role performed by KSC/ULO is launch operation integration and support. This role is carried on through coordination meetings and a formal Launch Operations Working Group. Areas covered include:

- Integrated planning
- Facilities
- Support services
- Launch vehicle processing
- Countdown procedures

KSC/ULO is organized to perform this role as shown in Figure 1-4. Project representatives are appointed for each program to function as the program interface at the launch site. A spacecraft coordinator is identified from the Spacecraft Operations and Vehicle Support Branch to act as the focal point for a specific spacecraft's operation activities and requirements. His duties include:

- Assisting in planning support and documenting requirements
- Preparing integrated plans and schedules
- Interfacing with Range on safety
- Coordinate handling and testing
- Performing liaison between launch vehicle operations and spacecraft operations

These functions are performed over the program cycle time frame.

A Launch Operations Working Group is organized by KSC/ULO prior to the arrival of a payload at the launch site. This group is chaired by the ULO launch vehicle operations manager and includes members from all ULO elements, launch vehicle system contractors, the Spacecraft Management Center, contractor

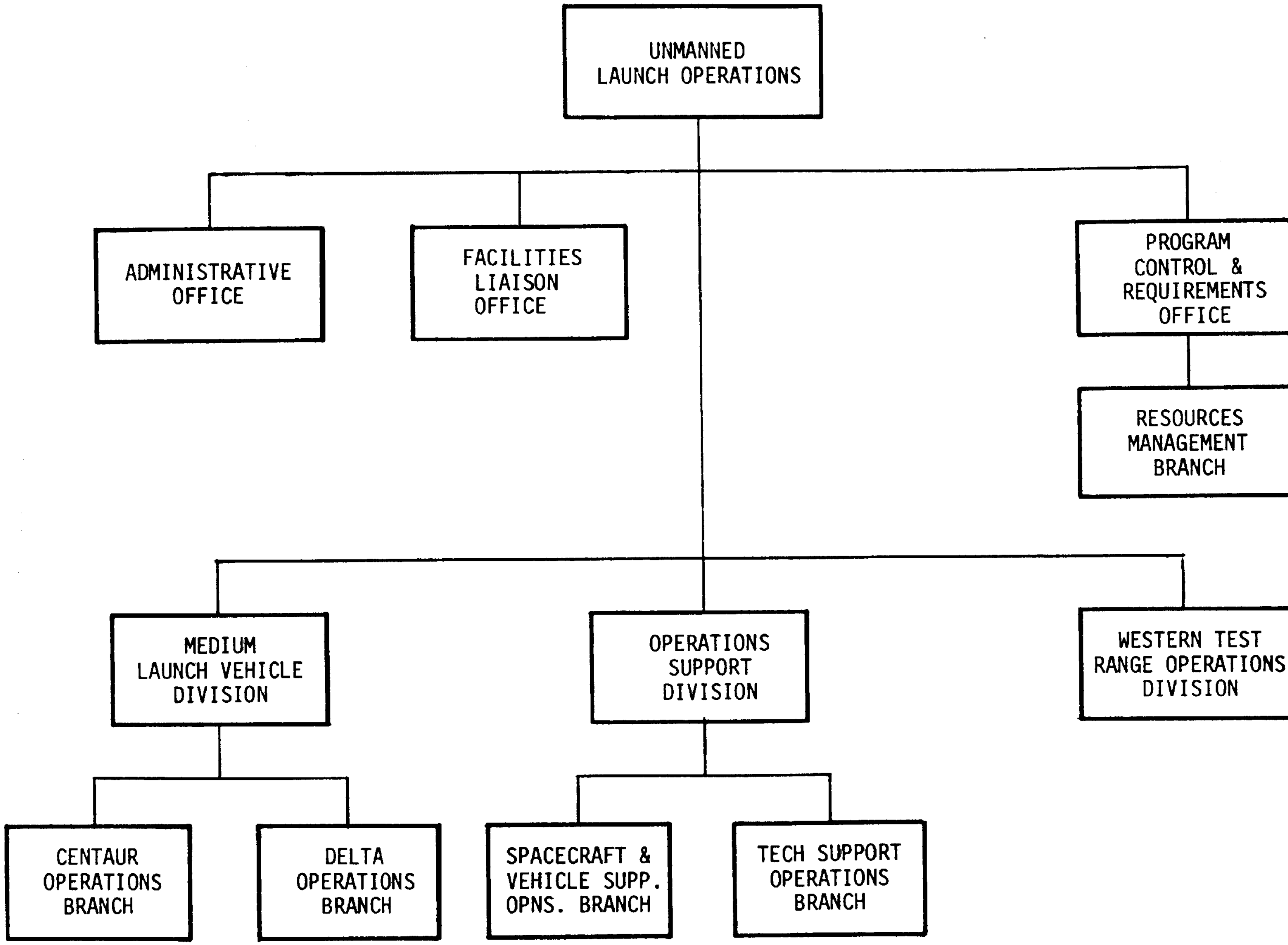

FIGURE 1-4. KSC/ULO ORGANIZATION

2.5.2 Management and Organizational Interfaces (Cont.)

personnel, and AFETR representatives. Through this group, all activities of the project are coordinated and scheduled. This group also holds readiness reviews and provides problem resolution capability.

2.5.3 KSC/ULO Involvement

KSC/ULO's involvement in the payload program is summarized in Table 1-1.

TABLE 1-1. KSC/ULO INVOLVEMENT

Conceptual	Development	Operation
• Inputs on facilities availability • Proposal review • Safety inputs	• Design reviews • Facility mods • Safety operation inputs • Handling and transportation inputs • Assist planning • Coordinate requirements	• Test procedure reviews • Scheduling operations • Provide facilities and services • Test planning • Integrate launch operations

2.5.4 Launch Operations

Launch operations for the payloads under discussion are initiated upon arrival of the spacecraft at ETR. KSC/ULO schedules and coordinates the off-loading, handling and transporting, checkout testing, and launch servicing. The Spacecraft Management Center provides direction for spacecraft operations. The spacecraft contractor performs the test and checkout functions with the experimenters standing by for consultation, if required. KSC/ULO performs as a host agency by providing direct support and coordination for support from other organizations when required. KSC/ULO will also perform whatever other duties have been delegated by the lead center. Launch readiness of the spacecraft is stated by the Spacecraft Management Center project manager. PI/experiment involvement in launch operations is minimal.

A typical organization make-up for a Delta or Centaur launch is as follows:

Payload:
- Payload Management Center
- Payload Contractor

2.5.4 Launch Operations (Cont.)

- Experimenters/PI's
- ULO

Boost Stage:
- Stage Management Center
- Stage Contractor
- ULO

Launch Vehicle:
- Launch Vehicle Management Center
- Launch Vehicle Contractor
- ULO

In addition to these NASA organizations, the AFETR and the Range contractor are involved in launch operations.

2.5.5 Documentation

Because the activities involved in launching of payloads on the Centaur and Delta vehicles create many NASA and government agency interfaces, a formal documentation system has evolved by which requirements and responses are transmitted. The origination and maintenance of payload program documents are the responsibility of the cognizant Spacecraft Management Center. KSC/ULO is responsible for the review, coordination, final processing, and submittal of all documents to KSC and the Air Force Eastern Test Range (AFETR).

ULO handbooks describe the documents, the purposes of each one, and the coordination required for AFETR support.

Table 1-2 provides a summary-type matrix for documentation interfaces for these payloads. Facility and support requirements are transmitted to KSC/ULO by the Interface Control Drawing (ICD) system and the Program Requirements Documents (PRD) system. The ICD's originate and are controlled by the Launch Vehicle Management Center. The requirements for the PRD's originate within the Spacecraft Management Center.

2.5.6 Program Cycle

The program cycle for the Centaur and Delta generally runs from three to five years. This is because the payloads have been large spacecraft with dedicated subsystems and experiments. Most of this time involves the design, fabrication and integration of the payloads, and experiments. The complexity of these payloads and the operational checkout requirements result in a launch site stay time which runs from four to seven weeks. This time span can be divided into the following increments:

DOCUMENTATION	SPACECRAFT MANAGEMENT	LAUNCH VEHICLE MANAGEMENT CENTER	ULO	AFETR	KSC	SPACECRAFT CONTRACTOR
ICD's	Originates	Inputs/Responds	Responds			Responds
Requirements Documentation	Inputs	Inputs	Originates	Responds	Responds	
Requirements Implementation			Originates	Responds		
Spacecraft Design Constraints	Transmits	Originates				Responds
Spacecraft Test Procedures	Originates	Inputs		Safety Approval	Safety Approval	Inputs
Launch Vehicle Test Procedures	Inputs	Inputs	Originates			
Test Plans and Schedules; Integrated Test Procedures	Responds	Responds	Originates	Responds	Responds	
Range Safety Documentation		Originates	Transmits	Approves	Approves	
Facility Requirements	Originates		Reviews		Responds	

TABLE 1-2. DOCUMENTATION INTERFACES

2.5.6 Program Cycle (Cont.)

- Industrial Area or checkout facility: 2-3 weeks
- Explosive Safe Area (if required): 1-2 weeks
- Launch Pad: 1-2 weeks

The facilities required for support during the launch site stay time must be scheduled years in advance.

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"Implementation of Research and Applications Payloads at the Shuttle Launch Site", Study Report, Contract NAS 10-7685, Martin Marietta Corp, January 1972.

Handbook of Unmanned Spacecraft Operations at ETR.

Handbook of ULO Facilities at ETR (Vol. I and II).

Handbook of Mission Operations and Communications at ETR.

2.6 APOLLO/SKYLAB PAYLOAD PROGRAMS

2.6.1 Apollo Payload Program

2.6.1.1 Program Objectives and Principal Features

The purpose of the Apollo experiment program is to obtain scientific data about the origin and evolution of the moon. This data is obtained by crew observations, laboratory investigations of lunar samples, active and passive lunar surface experiments, and remote sensor measurements from lunar orbit.

The principal program feature of the experiment program is that it has the same program requirements and controls as the spacecraft hardware. Examples of these requirements and controls are:

- Very strong emphasis on meeting performance requirements
- Severe weight and volume limitations and controls
- Flight hardware not recoverable for reuse
- Many end items required for most experiments (flight, flight backup, qualification, mockups and crew training hardware)
- Formal configuration management controls
- Extensive documentation requirements
- Extensive test program requirements and controls
- Formal reliability, quality, safety, and nonmetallic material programs
- Numerous procedures (crew training, flight, test, operating, maintenance, handling, etc.)
- Many formal program reviews (PDR, CDR, CARRs, etc.)

2.6.1.2 Organizational and Equipment Interfaces

NASA/MSC has the design, integration, crew training and operational responsibilities for Apollo experiments. The Principal Investigator (PI) defines the general requirements. NASA develops end item specifications and awards the contract to the successful bidder and monitors the contract. The experiment contractor is responsible for the design, development, qualification, acceptance testing, and the delivery of flight, flight backup, mockup, and crew training hardware. The flight and flight backup hardware is normally delivered to KSC for preinstallation testing (MSC developed procedures), installation into the spacecraft, and thermal vacuum testing. Mockup hardware is delivered to the

2.6.1.2 Organizational and Equipment Interfaces (Cont.)

spacecraft contractor (NR or GAEC) for verification of experiment/vehicle interfaces. Training hardware is delivered to MSC and/or KSC and used at the experiment contractor's facility for crew training.

The experiment contractor analyzes failures and performs required corrective actions on all failures which occur on delivered hardware. Hardware is shipped to the contractor's facility for this activity.

2.6.1.3 Documentation Requirements and Management System

NASA/MSC requires a closed-loop management system for the review and approval/disapproval of all Type I documents (submitted by contractor for approval) and many Type II documents (submitted by contractor for review). This management system involves formal correspondence to the experiment contractor with concurrences by the experiment technical monitor, support divisions such as Reliability and Quality Assurance, Apollo Program Office,and the signature of the NASA contracting officer. The management system also involves publication of status reports such as test start dates, completion dates, plans, requirements, procedures, and final reports; failure analysis and corrective actions; and failure modes and effect analysis and single failure point summaries.

The attached Skylab Documentation Schedule (at the end of Section 2) lists the documentation required for most major Apollo experiments. (The documentation requirements are tailored for each experiment but in most instances the majority of the listed documents are required.) The Documentation Schedule identifies the document, initial submittal requirements, when changes to the documents are required, and the type of documentation. (Type III documentation is not submitted but retained and made available to NASA upon requests)

2.6.2 Skylab Payload Program

2.6.2.1 Program Objectives and Principal Features

The purpose of the Skylab Program is to perform experiments in earth orbit to obtain scientific data for evaluation of earth resources, earth and solar system, and the medical effect of the zero gravity environment on the crew. This data is obtained by remote sensors and laboratory medical sensor systems which were developed for use in the zero gravity environment.

The principal program features for the Skylab experiment program are basically the same as the Apollo experiment program. The experiments and spacecraft have the same program requirements and controls except in the area of:

2.6.2.1 <u>Program Objectives and Principal Features</u> (Cont.)

- Qualification testing for earth resources and earth science experiments
- Reliability requirements and quality assurance inspection for earth resources and earth science experiments
- Experiment systems integration testing and checkout

Early in the Skylab Program an attempt was made to establish program requirements based on the following hardware categories:

<u>Category I</u> - Hardware containing equipment whose failure could adversely affect crew safety

<u>Category II</u> - Hardware containing equipment whose failure could result in not achieving a primary mission objective

<u>Category IIIA</u> - Hardware containing equipment whose failure could result in not achieving a secondary mission objective but which does not adversely affect crew safety or preclude the achievement of any primary mission objective

<u>Category IIIB</u> - Hardware containing no equipment whose failure could result in loss of primary or secondary mission objectives or adversely affect crew safety.

No practical method was developed which permitted one to tailor program requirements based on these hardware categories. This approach was aborted. It is also believed there was strong pressure by the NASA technical monitors (and their divisions) and groups within the Program Office to minimize the possibility of flight failures. The implications and postflight investigations associated with Apollo experiment flight failures had a large impact on the Skylab experiment program.

Earth resource and science experiment programs eliminated one hardware end item by refurbishment of the qualification hardware for use as the flight backup hardware. Development testing data was also used to satisfy some of the qualification test requirements (humidity and vibration) which could increase the cost of refurbishing the qualification hardware.

Reliability requirements for controlled electrical piece parts (screen and burn, and use of qualified parts, etc.) were softened and the requirements for quality assurance inspection were reduced for earth resources and earth science experiments.

Integrating contractors (MMC, MDAC-E, and MDAC-W) and NASA centers (MSC, MSFC, and KSC) performed extensive bench tests, fit and check, integrated system tests, and crew training exercises on groups of experiments. The experiment

2.6.2.1 Program Objectives and Principal Features (Cont.)

contractors were required to refurbish this hardware for flight use in most cases. The paperwork to ship and manpower required to control and monitor these activities at the numerous user sites was significantly greater than for the Apollo experiment program.

2.6.2.2 Organizational and Experiment Interfaces

The PI and experiment contractor relationship with the NASA center responsible for the experiment design are the same as for Apollo. The major differences between the Skylab and Apollo experiment programs are:

- Cluster requirements which were imposed by MSC on their experiment contractors were obtained from MSFC, the lead center for the cluster.
- MSC responsible for certifying the crew safety aspects for the spacecraft and cluster modules.
- ICD's, interface waivers, safety, single failure point summaries, etc. required joint MSFC-MSC approvals.
- MSFC responsible for experiment/module interface testing at MDAC-E, MDAC-W and MSFC.
- Experiment contractors required to refurbish their experiment hardware after above tests for reuse as flight or training hardware.
- Experiment/module interface testing and experiment systems test procedures provided by MSFC and MSC. Both centers also provide manpower for monitoring tests.
- Specialized long duration testing required for medical experiments. SMEAT (Skylab Medical Equipment Altitude Test) was performed to demonstrate the capability of crew and hardware to perform tasks to preliminary time line for 56 days in a test chamber pressurized to 5 psi.
- Thermal vacuum integrated system tests will not be performed at KSC with cluster modules.

2.6.2.3 Documentation Requirements and Management Systems

The management system used for review and approval/disapproval of Skylab experiment documentation is basically the same as that used for the Apollo Program. The documentation requirements for each experiment contract were tailored similar to that which was accomplished on the Apollo Program. The majority of the documents listed on the attached Document Schedule were required for major experiments.

DOCUMENTATION SCHEDULE
FOR
SKYLAB EXPERIMENTS

DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
End Item Specifications			
a. Flight Hardware	This document will be prepared and approved prior to the initiation of any development effort.	As required - by ECP/SCN	I
b. Mockup Hardware	2 weeks prior to Flight Hardware PDR	"	I
c. Mass Mockup Hardware	"	"	I
d. Zero Gravity Type Training Hardware	"	"	I
e. Neutral Buoyancy Type Training Hardware	"	"	I
f. Simulation Devices	"	"	I
g. Simulators	"	"	I
h. Ground Support Equipment	"	"	I
Configuration Specifications			
a. Section I - Design Approach	2 weeks prior to applicable PDR	As required - by ECP/SCN until approval of Section II - no changes required after approval of Section II	I
b. Section II - Detail Design	2 weeks prior to applicable CDR	As required - by ECP/SCN	I
c. Section III - Qualification Status	3 months after applicable PDR	Once/Month	II
d. Section IV - Configuration Status	2 weeks prior to applicable PDR	Once/Month	II

DOCUMENTATION SCHEDULE (Cont.)

DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
Engineering Change Proposals (ECP's)	As required	As required prior to approval of ECP	I
Specification Change Notices (SCN's)			
a. Preliminary	As required	As required prior to approval of SCN	I
b. Final	1 week after receipt of approval of Preliminary SCN	Not applicable	II
Specification Change Logs	With first final SCN for each specification and as required in Instruction for Preparation of a Specification Change Log	With each subsequent Final SCN for each specification	II
Specification Revision Charts	With first revision of each specification	With each subsequent revision of each specification	II
Engineering Drawings (including referenced documents)	As completed	Engineering Orders immediately after approval and revisions immediately after incorporation on the drawings	II
Technical Reports			
Load analyses, stress analyses, tradeoff studies, results of design reviews, EEE parts design deratings and screening procedures, numerical reliability tradeoff studies, etc.	To be available at PDR	As required - to be available at CDR	III

DOCUMENTATION SCHEDULE (Cont.)

DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
Review Minutes			
a. Part A	1 week after completion of applicable Review	As required	II
b. Part B	No later than 1 month after the applicable Review	As required	II
Acceptance Review Reports	To be delivered with applicable hardware after acceptance	Not applicable	II
Management Plan	2 months after contract award	As required	I
Failure and Unsatisfactory Condition Reports			
a. All	Within 5 days after failure isolation	As required	II
b. Significant Nonconformances	Within 24 hours after failure isolation - by telephone	As required	II
Failure Analysis and Corrective Action Reports			
a. Those not requiring baseline changes	Within 25 days after failure isolation	As required	II
b. Those requiring baseline changes	Within 10 days after failure isolation - with ECP	As required	I
	Final - within 15 days after ECP approval		II

DOCUMENTATION SCHEDULE (Cont.)

DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
Acceptance Data Package	To be available at applicable Acceptance Review - to be delivered with applicable hardware after acceptance	As required as the result of action items from the Acceptance Review	II
Material Review Records	To be available at all times for inspection and review with the equipment	As required	III
Equipment Logs	To be available at all times for inspection and review with the equipment - to be delivered with applicable hardware after acceptance	As required as the result of inspection and reviews	II
Failure Mode and Effects Analyses Report			
a. Preliminary	2 weeks prior to PDR	As required	II
b. Final	2 weeks prior to CDR	As required	II
c. Single Failure Points	Initially submitted as part of the FMEA	After PDR - within 24 hours	II
EEE Parts List	2 weeks prior to PDR	As required	II
Nonmetallic Materials List	2 weeks prior to PDR	As required	II
EEE Parts Specifications	To be available at PDR	As required	III
Verification Plan	2 weeks prior to applicable PDR for review	As required	II
	1 month after applicable PDR for approval	As required	I

DOCUMENTATION SCHEDULE (Cont.)

DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
Test Specifications			
a. Development Test Specifications	1 month prior to start of applicable tests	As required	II
b. Qualification Test Specifications	2 weeks prior to applicable CDR	As required	II
c. Acceptance Test Specifications	2 weeks prior to applicable CDR	As required	II
d. Preinstallation Test Specifications	2 months after start of qualification test	As required	II
e. Test Specification for use in preparation of Integrated Systems Test Specification	1 month after start of qualification test	As required	II
Test Procedures			
a. Development Test Procedures	Not required	As required	III
b. Qualification Test Procedures	1 month prior to start of qualification tests	As required	II
c. Acceptance Test Procedures	1 month prior to start of acceptance tests	As required	II
d. Preinstallation Test Procedures	2 months after submittal of Preinstallation Test Specification	As required	II
Test Reports			
a. Development Test Reports	Not required	As required	III
b. Qualification Test Reports	1 month after completion of test	As required	I

DOCUMENTATION SCHEDULE (Cont.)

DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
Calibration Data Reports	2 weeks prior to applicable Acceptance Review	As required	II
Development Status Reports	3 months after start of development effort - once/month thereafter	Not applicable	II
Operating, Maintenance and Handling Procedures	2 weeks prior to applicable CDR	As required	II
Experiment Hardware Support	2 weeks prior to Flight Hardware PDR for Review	As required	II
	1 month after Flight Hardware PDR for approval	As required	I
Spares Requirements	2 weeks prior to applicable CDR	As required	I
Reports of Experiment Results	*		

*As defined in Flight Hardware End Item Specification

Bibliography

"Apollo Applications Program Experiment Hardware General Requirements Document", MSC-KA-D-68-1 Rev. B

Private Communication, M. T. Lee, MSC-NB5

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SECTION 3 - SURVEY, ASSEMBLE AND ORGANIZE PAYLOAD DATA

3.1 SOURCES

The objective of Task 1 is to define a baseline set of representative experiment hardware suitable for the Quick-Reaction (QR) Sortie mode of operation (Table 1-3). Later tasks use this representative baseline set as the basis for developing ground operations and resource requirements for the QR integration concept.

The sources of potential experiments were given in Appendix "A" of the contract Statement of Work. These sources include the "Green Book", Skylab experiments, and the RAM and SOAR studies (References 1 through 5).

The selection criteria used to screen this particular experiment market included the criteria developed earlier in the definition of the QR concept as well as the basic Sortie Lab and Shuttle Orbiter capabilities.

3.2 SORTIE LAB CAPABILITIES

The capabilities of the basic Sortie Lab for experiment and mission support are those delineated in References 6, 7, and 8. A brief description of these support capabilities is presented in the following paragraphs.

3.2.1 General Mission Characteristics

Sortie Lab missions are nominally performed over a seven-day period in low earth orbit at altitudes between 100 and 235 nautical miles. All orbit inclination capability is provided. The Sortie Lab operates attached to the Shuttle in orbit.

3.2.2 Crew

Nominally, a crew of two to four flight experiment operators is available to man the Sortie Lab and to operate the experiment hardware.

3.2.3 Sortie Lab Facilities

The basic Sortie Lab is a pressurized cylinder with two removable end bulkheads.

Dimensionally the cylinder has a diameter of 14 feet and a length of 240 inches. The bulkheads are 33 inches deep thus giving a total length of 306 inches. The Sortie Lab subsystems and general support equipment occupy a portion of the forward half of the available mounting space. The remaining space is available for experiment hardware and equipment installation.

Accommodations within the Lab include: a crew station console for monitoring systems and experiment operation; a work bench for general operation support; standard equipment racks; equipment structural support; storage space; standardized connectors for power, data, vacuum and lighting; airlocks; viewports.

3.2.4 Payload Weight

The maximum weight available for the experiment complement of the Sortie Lab has been defined for planning purposes. This weight is obtained by taking 80% of the basic Shuttle payload capability for a given orbit and then subtracting the weights of the basic Sortie Lab elements. The basic Sortie Lab with systems is estimated to be 12,000 lbs. and the 30 foot pallet is 1,200 lbs. However, proposed Sortie Lab mission configurations in the referenced documentation indicate experiment complements on the order of 5,000 lbs.

3.2.5 Electrical Power

The electrical power is supplied by fuel cells providing 1.5 to 2.0 KW average and 3.0 to 5.0 KW peak power at 30 volts d.c. on orbit. An inverter is available to supply a.c. power.

3.2.6 Environmental Control

The Environmental Control and Life Support System (ECLSS) maintains the oxygen/nitrogen atmosphere at 14.7 PSIA and 72 $\pm$ 5°F. The on-orbit capability of the active thermal control system is 5120 btu/hr for experiments. The volume is maintained to a cleanliness of class 100,000.

3.2.7 Data Acquisition

The data acquisition system uses a two-wire party line approach to gather data from remote points. The highest system bit rate is 102.4 bits/sec. Experiments requiring higher bit rates or analog data are hardwired directly to recorders or computer input/output. The principal components of the data acquisition system are the Remote Acquisition Units (RAU's), the Flexible Format Generator (FFG), and the Digital Control Combiner Unit (DCCU).

3.2.8 Data Storage and Processing

Three basic types of magnetic tape recorders are available. Their characteristics are as follows:

- Large Volume
  - 60 inches/sec
  - 1 inch tape width
  - 28 tracks
  - 20,000 bits/inch/track
  - Reel capacity: 10 1/2 inches - 4600 ft; 14 inches - 9200 ft
- Medium Capacity
  - Up to 60 inches/sec
  - 1 inch width
  - 14 tracks
  - 10,000 bits/inch/track
  - Reel Capacity: 10 1/2 inches - 4600 ft
- Video Recorder
  - 15 inches/sec
  - 4.25 MHz video bandwidth
  - 96 minutes recording time (7200 ft)

The computer portion of the Data Management System (DMS) consists of a processor, memory, and input/output (I/O). Its primary function is experiment control and sequencing through coordinate conversions and data correlation. Some data reduction may be performed for quick-look analysis. Typical characteristics are:

Word length:	16 bits
Memory size:	16K x 16 bit words
Instructions:	Typical minicomputer instruction set including multiply, divide, fixed and floating point
Software:	Fortran compiler, assembler, emulator, and diagnostic routines

3.2.9 Data Sequencing and Control

The DMS receives and can display state vector information from the Shuttle. This includes position, velocity, body rates and attitude, time, altitude, and other selected data as required by the experiments. This data is utilized by the DMS or the experiments as necessary for support.

3.2.10 Communications

All communications are through the Shuttle communications system via standard lab interfaces. Requirements exceeding this capability are handled by equipment added to the Sortie Lab. The following capabilities are available to the Sortie Lab through the Shuttle:

- Two-way voice between the payload bay and the Shuttle
- Conference capability with the ground during periods of communications coverage.
- 25K bits/sec total digital data allocation shared by all payloads when interleaved with Orbiter downlink data
- 256K bits/sec via hardwire input to the Orbiter telemetry encoder, when no Orbiter data are transmitted
- A hardwired input to the Orbiter wideband transmitter carrier for attached payloads.
- The Sortie Lab provides commutation and subcarrier oscillators compatible with the Orbiter transmitter circuitry. For digital data the payload provides the required encoding for compatibility with the Orbiter transmitter.

3.3 SHUTTLE ORBITER CAPABILITIES

The Orbiter capabilities for the support of payloads and experiments are concerned more with performance capabilities and support to automated and kick-stage assisted payloads. Since the proposed orbiter capabilities are more well known and the literature is readily available it was not deemed necessary to repeat it here.

3.4 FUTURE CHANGES IN ORBITER AND SORTIE LAB CAPABILITIES

Both the Orbiter and the Sortie Lab are currently in preliminary stages of design, with the Orbiter somewhat more defined. The capabilities of the Sortie Lab given here is based on material available to the study team. Undoubtedly specifics will change as the design concept matures and requirements are refined. The reader, if performing detailed experiment planning for the Sortie Lab, is

3.4 FUTURE CHANGES IN ORBITER AND SORTIE LAB CAPABILITIES (Cont.)

advised to obtain the latest available data on the Sortie Lab from the Sortie Lab Program Office at MSFC.

References

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4. "Skylab Program Operational Data Book", Volume I, Experiments Performance Data, Manned Spacecraft Center, MSC-01549, September 1970
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6. "Sortie Can Conceptual Design", ASR-PD-DO-72-7, MSFC, 1 March 1972
7. "Sortie Lab System Utilization Characteristics", MSFC, 27 June 1972
8. "Sortie Lab Guidelines and Constraints, Level 1", Revision 1, Office of Manned Space Flight, NASA, 15 August 1972
9. "Space Shuttle Baseline Accommodations for Payloads", Manned Spacecraft Center, MSC-06900, 27 June 1972
10. "Space Shuttle Presentations for the NASA Space Shuttle Sortie Symposium/ Workshops Held at the Goddard Space Flight Center July 31 through August 4, 1972", MSC, 31 July 1972
11. "Space Shuttle Program Request for Proposal", RFP No. 9-BC421-67-2-40P, MSC, 1972

EXPERIMENT	WT LB	DIMENSIONS IN.	POWER AVG WATTS	POWER PEAK WATTS	DATA ACQUISITION	DATA DISPOSITION - PCT REAL-TIME DOWNLINK	ON-ORBIT DISPLAY	RETURN SHUTTLE	ORBITER MANEUVER REQUIREMENTS	POINTING ACCURACY DEGREE	ENVIRONMENTAL REQUIREMENTS CLEAN CLASS	PRESS PSI	HUMIDITY PCT	TEMP °F	SPECIAL FACILITIES	CHECKOUT AREA SQ FT
SMALL UV TELESCOPE	750	6.0 x 4.0 x 2.5 FT	20	45	FILM & DIGITAL - 500 BPS	100	100	100	MUST VIEW DIFFERENT SEGMENTS OF CELESTIAL SPHERE	±0.5	MOD	0 - 15	50	14 - 77	OPTICAL LAB PHOTO LAB	1000
IMAGE ISOCON TELEVISION	46	7.5 x 7.0 x 21.0	70	110	MAG TAPE - 240 KHz	-	10	100	NA	±0.5	100,000	15	<50	50 - 90	OPTICAL LAB	300
PHOTOMETRIC CLUSTER	30	24 x 12 x 12	25	110	MAG TAPE - 82 KBPS	-	10	100	NA	±0.5	100,000	15	<50	50 - 90	OPTICAL LAB	300
MASS SPECTROMETER	16	8 x 10 x 10	8	8	MAG TAPE - 405 BPS	-	50	100	ATTITUDE TO POINT AWAY FROM EARTH	NA	MOD	15	<50	50 - 90	OPTICAL LAB	300
ION TRAP	7.5	7 x 8 x 10	10	10	MAG TAPE - 1080 BPS	-	50	100		NA	MOD	15	<50	50 - 90		300
ELECTROSTATIC PROBE	3.0	4 x 5 x 3.5	2	2	MAG TAPE - 540 BPS	-	50	100		NA	MOD	15	<50	50 - 90		300
ELECTRIC FIELD PROBE	30	10 DIA x 6	10	10	MAG TAPE -540 BPS	-	50	100		NA	MOD	15	<50	50 - 90		300
FLUX GATE MAGNETOMETER	6	6 x 6 x 6	5	5	MAG TAPE - 900 BPS	-	50	100		NA	MOD	15	<50	50 - 90		300
OPTICAL METEOROID DETECTOR	75	39 DIA x 39	7.5	110	MAG TAPE - 264 BPS	-	10	100	POINT AWAY FROM EARTH AVOID SHADOWING	±2.0	100,000	15	<50	50 - 90	OPTICAL LAB	300
MULTISPECTRAL RADIOMETER	40	10 DIA x 24	20	20	MAG TAPE - 2.7 KBPS	10	-	90	PRIMARY POINTING MODE IS TO NADIR	±0.5	100,000	0 - 15	30 - 70	45 - 81	OPTICAL LAB	1000
MICROWAVE RADIOMETER	450	30 dia x 36	160	160	MAG TAPE - 384 BPS	10	-	90		±1.0	MOD	0 - 15	<50	50 - 90	RF LAB	500
MULTISPECTRAL CAMERA	590	24 x 24 x 15	30	275	FILM	-	-	100		±0.5	MOD	0 - 15	<50	60 - 90	OPTICAL LAB PHOTO LAB	1000
MULTISPECTRAL SCANNER	300	30 x 20 x 60	115	270	MAG TAPE - 970 KBPS	10	-	90		±2.5	100,000	0 - 15	<50	-20 - 160	OPTICAL LAB	300
PASSIVE MICROWAVE SCANNER	250	13 x 1 x 13 FT	175	175	MAG TAPE - 2 KBPS	10	-	90		±1.0	MOD	0 - 15	<50	45 - 81	RF LAB	500
PLASTIC/NUCLEAR EMULSION	308	36 x 36 x 6	3.5	22	EMULSION SHEETS	-	-	100	ANY ATTITUDE IN ZENITH HEMISHPERE	±1.0	MOD	0 - 15	<50	40 - 90	STORAGE FOR EMULSION SHEETS	300
UV AIRGLOW HORIZON PHOTOGRAPHY	40		NA	NA	FILM	-	-	100	POINTING TOWARD EARTH'S HORIZON	±0.5	100,000	0 - 15	<50	40 - 90	OPTICAL LAB PHOTO LAB	300
UV X-RAY SOLAR PHOTOGRAPHY	25	6 x 6 x 16	7	70	FILM	-	-	100	VARIOUS ATTITUDES AWAY FROM EARTH	±0.5	100,000	0 - 15	<50	-40 - 160	OPTICAL LAB PHOTO LAB	300
L-BAND RADIOMETER	53		30	35	MAG TAPE - .18 KBPS	-	-	100	VARIOUS ATTITUDES TOWARD EARTH	±2.5	MOD	0 - 15	<50	20 - 180	RF LAB	500
SURFACE MOISTURE PHOTOPOLARIMETER	30	24 x 24 x 42	550	700	MAG TAPE - 970 BPS FILM	50	50	100	VARIOUS ATTITUDES TOWARDS EARTH	±0.5	100,000	0 - 15	<50	40 - 90	OPTICAL LAB PHOTO LAB	300
DOSIMETER	8	4 x 7 x 5	.8	.8	MAG TAPE	100	-	100	NA	NA	MOD	0 - 15	<50	-40 - 160		300
THERMAL COATINGS	6	8 x 8 x 5	NA	NA	SAMPLE PANELS	-	-	100	SAMPLES TO BE ORIENTED TOWARDS SUN	NA	MOD	0 - 15	<50	-135 - 200		300
IN-FLIGHT AEROSOL ANALYSIS	8	8 x 4 x 6	NA	NA	DIGITAL DISPLAY	-	100	100	NA	NA	100,000	0 - 15	<50	40 - 90		300
EFFECT OF ZERO G ON SINGLE HUMAN CELL	23	15 x 9 x 6.5	25	135	FILM	-	-	100	NA	NA	100,000	0 - 15	<50	50 - 95	BIO LAB PHOTO LAB	1000
CIRCADIAN RHYTHM	227	43 x 24 x 19	193	237	SELF-CONTAINED COMPUTER PROCESSING AND STORAGE	100	-	100	NA	NA	100,000	0 - 15	<50	65 - 70	BIO LAB	1000

TABLE 1-3. BASELINE EXPERIMENT HARDWARE

SECTION 4 - GROUND OPERATIONS REQUIREMENTS

4.1 INTRODUCTION

This section presents the launch site ground operations functional flow diagrams for the various Quick-Reaction Sortie mode experiment groups. The time phased relationship of the experiment groups to the carrier and the Orbiter are included.

4.2 LAUNCH SITE GROUND OPERATIONS

The following paragraphs describe the ground operations for each Quick-Reaction Sortie experiment group. The experiments have been categorized into six groups. The groups are primarily based on the integration and checkout requirements. Table 1-4 lists the experiment groups. A functional flow diagram of the activities at the launch site is presented in Figure 1-5. Timeline flow diagrams for each experiment group are also shown to provide a graphic view of the pre-installation sequence of operations and the amount of time estimated to be involved (see Figures 1-6 through 1-13). The applicable portions of the ground operations flow diagrams for the Sortie Lab and the Shuttle are shown so that time phasing between all three elements is apparent. These diagrams show the ground operations from just prior to experiment arrival at the launch site through launch and recovery. The time scale shown on the flow diagrams is read horizontally, in working hours, from left to right, beginning with experiment hardware arrival at zero hours. The major activities are shown in the left-hand vertical column. The sequence of the operations performed are indicated by a bar to the right. The length of the bar indicates the time required. The sequence of operations at the launch site is anticipated to be about the same, with some exceptions for each of the experiment groups. This sequence generally follows the pattern of shipping, receiving-inspection, equipment setup, experiment hardware checkout, experiment calibration, installation into the experiment carrier with other experiments, integration tests, installation into the payload bay of the Orbiter, mating, move to the launch pad, and launch.

TABLE 1-4. EXPERIMENT CATEGORIES

(Weight and volume of each experiment is in parentheses after the title)

GROUP A - CAMERAS WITH OPTICS

- UV X-Ray Solar Photography (25 lbs; 1 CF)
- UV Airglow Horizon Photography (40 lbs; 2 CF)
- Multispectral Camera (590 lbs; 5 CF)
- Small UV Telescope (750 lbs; 60 CF)
- Image Isocon TV (46 lbs; .65 CF)

GROUP B - LIGHT SPECTRUM SENSORS

- Multispectral Radiometer (40 lbs; 1 CF)
- Photopolarimeter (30 lbs; 14 CF)
- Multispectral Scanner (300 lbs; 23 CF)
- Optical Meteoroid Detector (75 lbs; 25 CF)
- Photometric Cluster (30 lbs; 2 CF)

GROUP C - ELECTROSTATIC & MAGNETIC FIELD SENSORS

- Electrostatic Probe (3 lbs; 70 CI)
- Electric Field Meter (30 lbs; 2 CF)
- Flux Gate Magnetometer (6 lbs; 216 CI)

GROUP D - RF SENSORS

- Microwave Scanner (250 lbs; 17.6 CF)
- Mirrowave Radiometer (450 lbs; 14 CF)
- L-Band Radiometer (53 lbs; 4 CF)

GROUP E - AMBIENT ENVIRONMENT SENSORS

- Plastic/Nuclear Emulsion (308 lbs; 5.5 CF)
- In-Flight Aerosol Analysis (8 lbs; .2 CF)
- Dosimeters (Passive & Active) (.4 lb; 10 CI)
- Thermal Coatings (4 lbs; .2 CF)
- ION Trap (7.5 lbs; .4 CF)
- Mass Spectrometer (16 lbs; .45 CF)

GROUP F - BIOLOGICAL INSTRUMENTS

- Circadian Rhythm (227 lbs; 11.5 CF)
- Effect of Zero G on Single Human Cell (23 lbs; .53 CF)

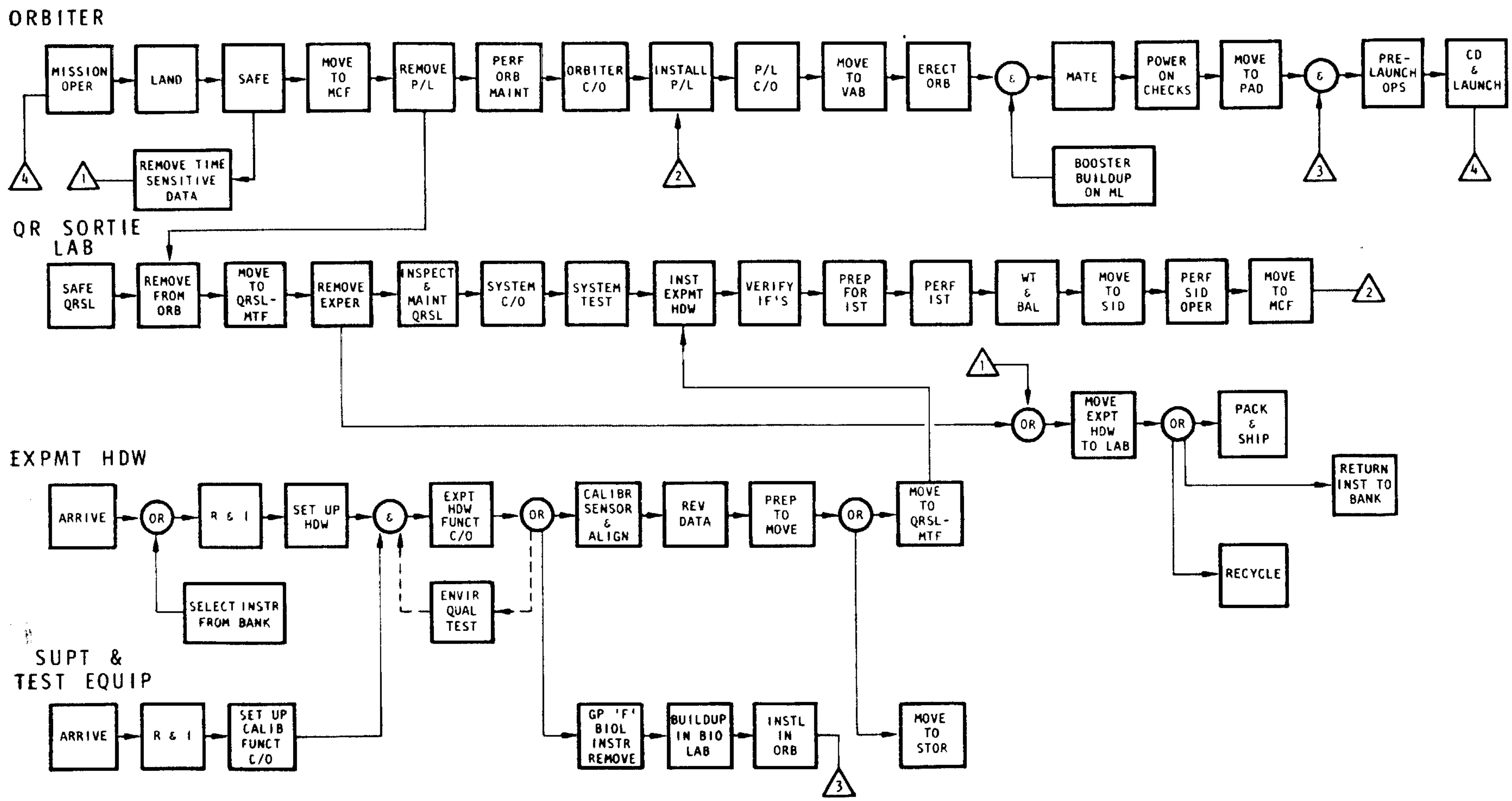

FIGURE 1-5 GROUND OPERATIONS REQUIREMENTS FUNCTIONAL FLOW DIAGRAM

4.2.1 Experiment Ground Operations

The experiment ground operations discussed in this section indicate the functions performed on all of the experiment groups. Special considerations for each group are described separately. Preintegration activity timeline flow diagrams are shown in Figures 1-6 through 1-13.

All of the Quick-Reaction experiment hardware, in addition to being categorized into one of the previous groups, is also designated as being Type I, II, or III hardware. These designations mean:

Type I	-	Hardware which has satisfactorily flown in space before.
Type II	-	Hardware which has not flown before but is flight certified by NASA, DOD or another qualified source.
Type III	-	Hardware which has neither flown before nor is flight certified.

The Type III hardware, because its behavior is an unknown quantity, is required to go through an environmental qualification test series to demonstrate that it is safe and compatible with the other mission objectives. The tests on this hardware consist primarily of simulated temperatures, altitudes, and vibrations likely to be encountered during the mission. The tests are not intended to demonstrate that the hardware will operate while exposed to these parameters.

These tests need not be performed at the launch site. Any qualified commercial, private, or other government testing laboratory can certify that the hardware meets the necessary certification specifications. For this study, the ground operations reflect the baseline of performing these tests at the launch site. Consequently, the test equipment and facility for this testing is included in the analysis. It is estimated that an additional 68 working hours must be added to the timelines for performing the environmental qualification tests. The experiment hardware functional flow of ground operations indicates these tests are performed after the initial functional checkout. After the qualification tests, the hardware is returned to the local PI lab and the functional checkout is repeated. This provides a basis for determining whether there is any degradation in the operation and/or capability of the hardware as a result of the tests. A timeline for the environmental qualification testing of Type III hardware is shown in Figure 1-14.

Some Type III hardware will not require these tests for one reason or another. Consequently, a procedure should be set up to handle waivers of these tests.

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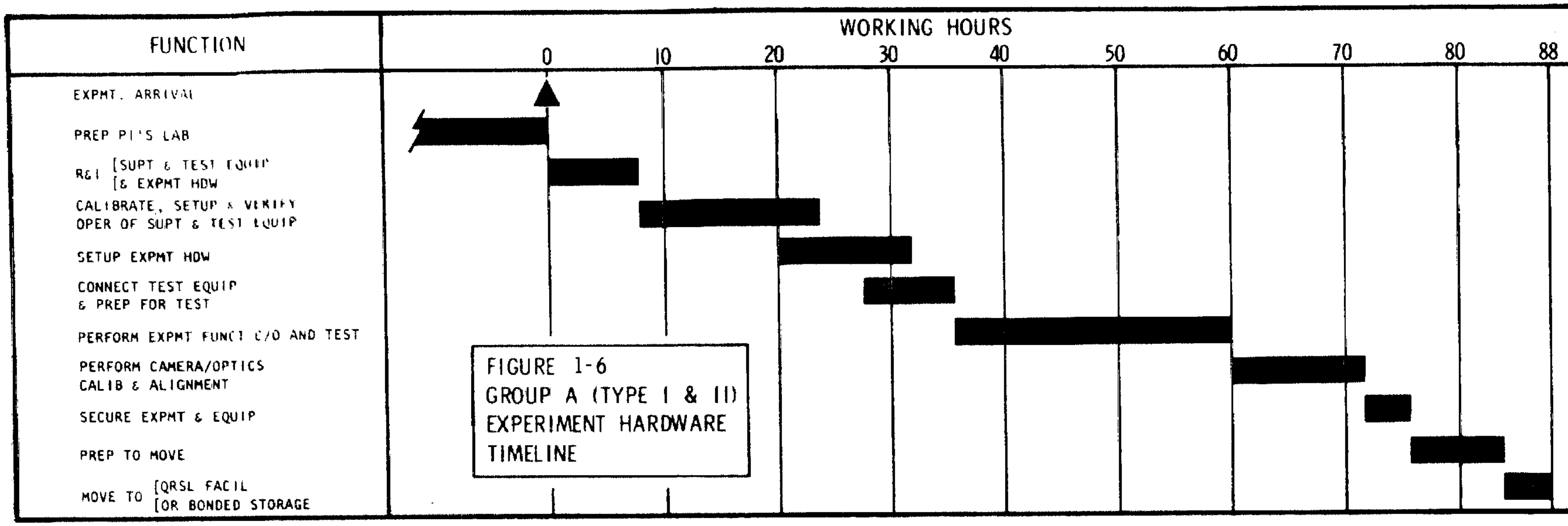

FIGURE 1-6
GROUP A (TYPE I & II)
EXPERIMENT HARDWARE
TIMELINE

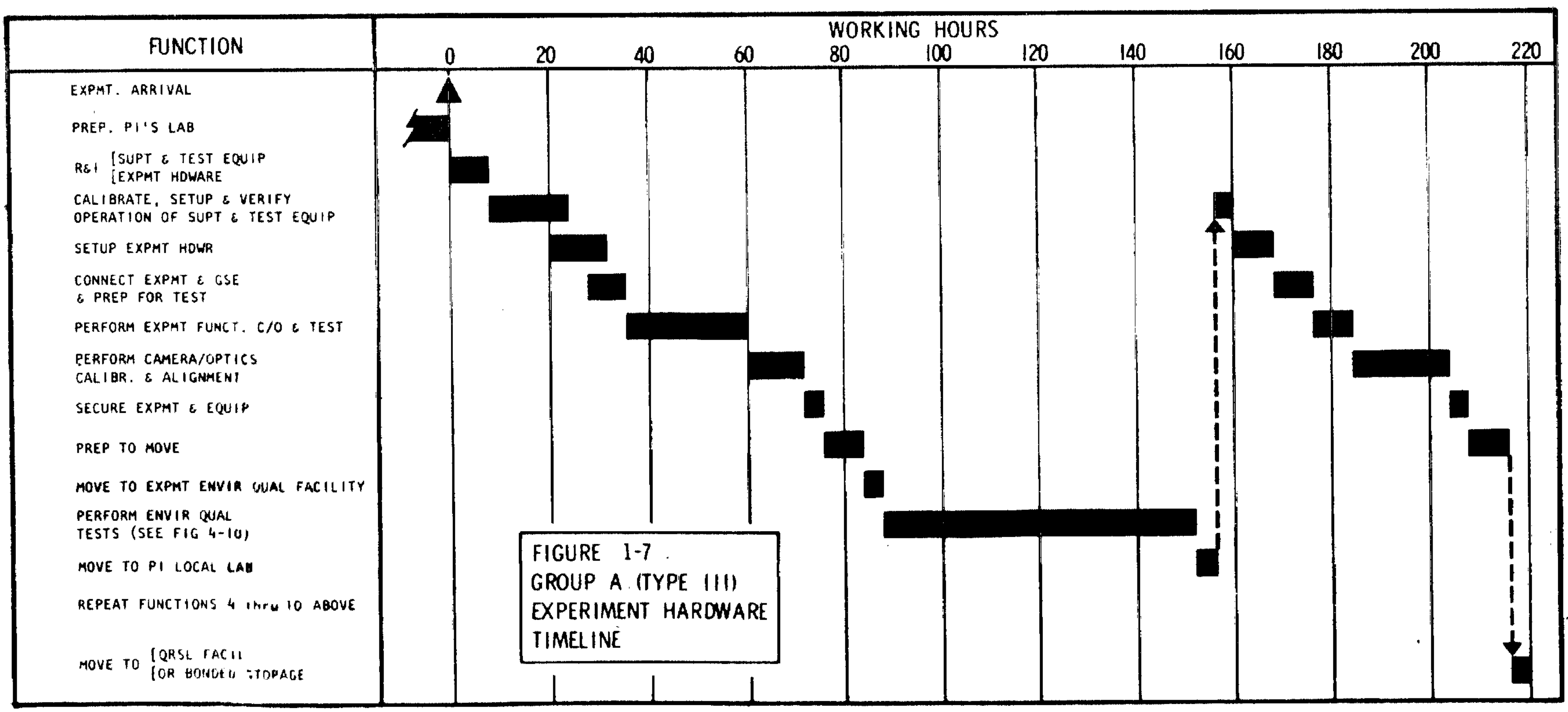

FIGURE 1-7
GROUP A (TYPE III)
EXPERIMENT HARDWARE
TIMELINE

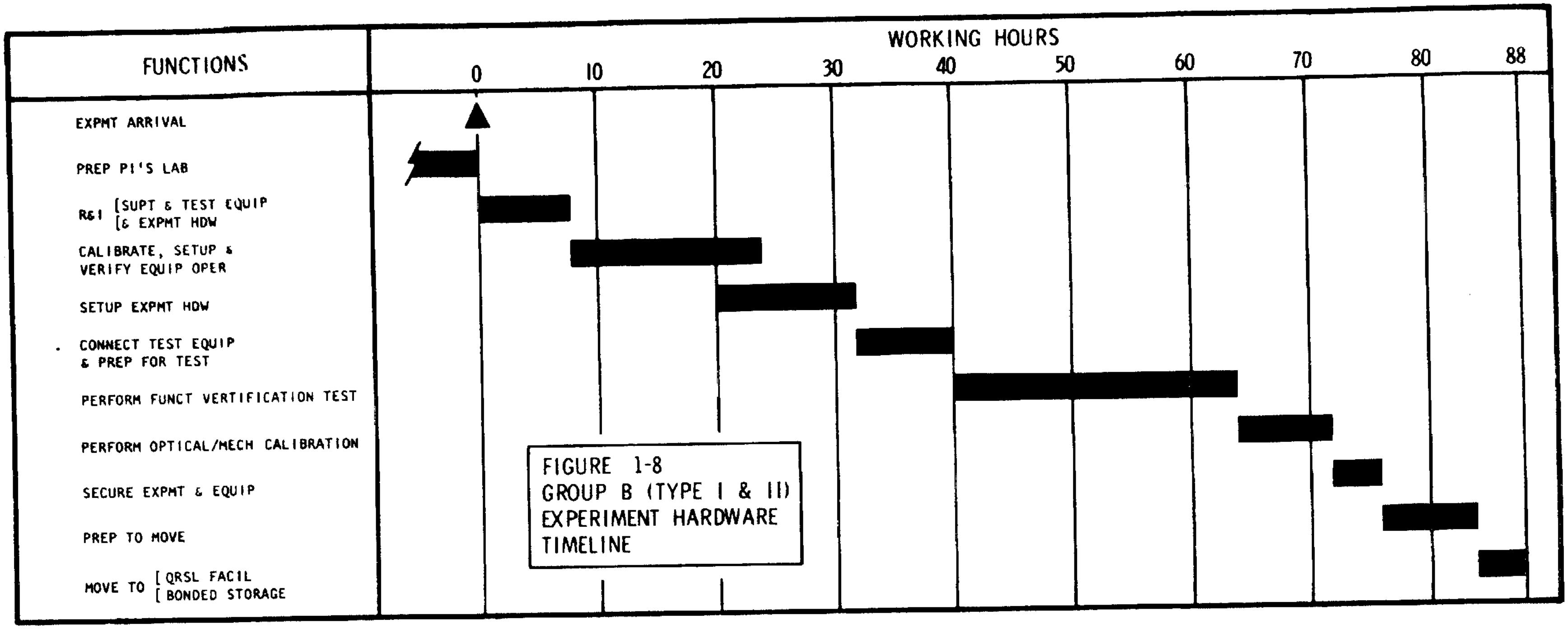

FIGURE 1-8
GROUP B (TYPE I & II)
EXPERIMENT HARDWARE
TIMELINE

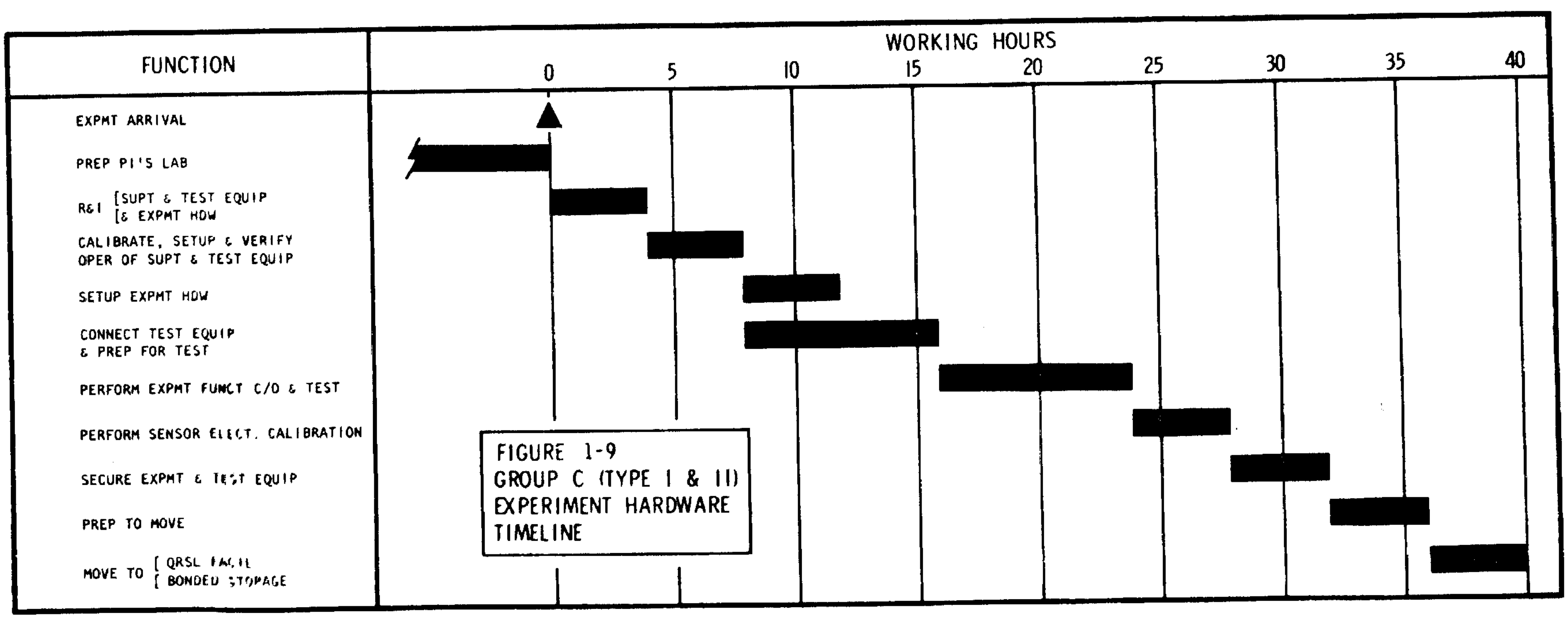

FIGURE 1-9
GROUP C (TYPE I & II)
EXPERIMENT HARDWARE
TIMELINE

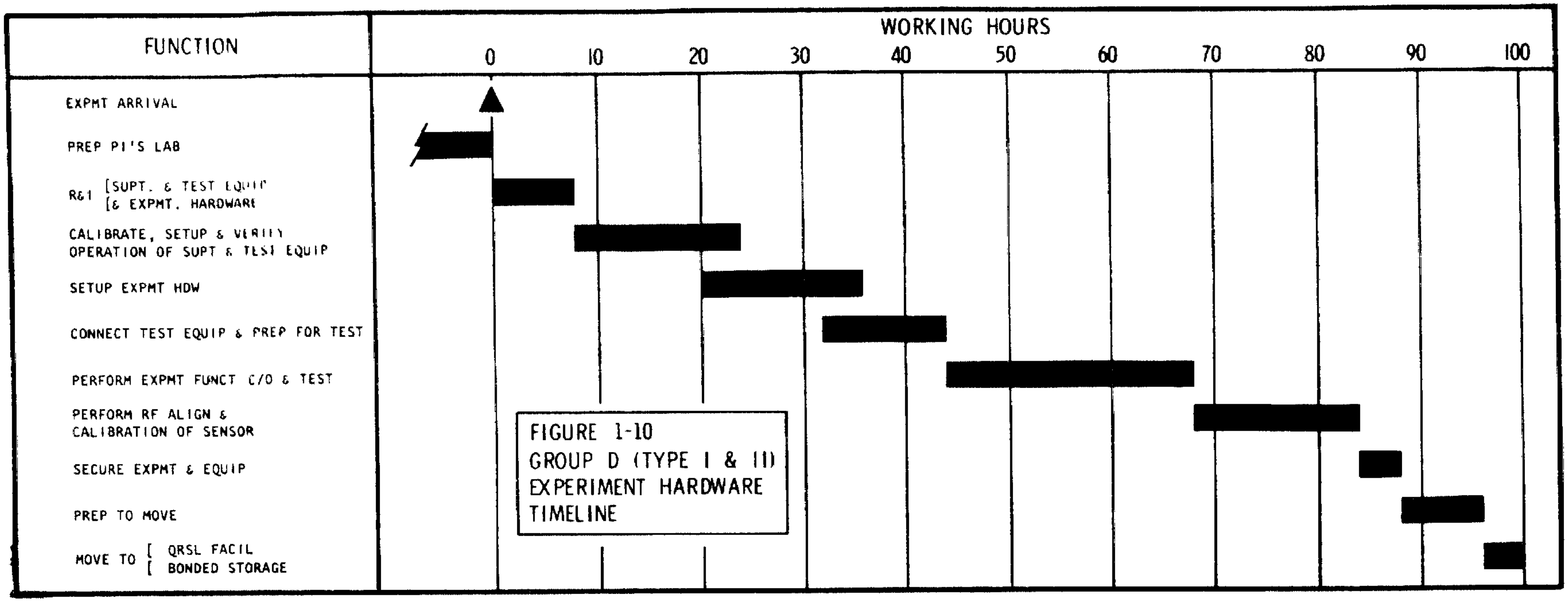

FIGURE 1-10
GROUP D (TYPE I & II)
EXPERIMENT HARDWARE
TIMELINE

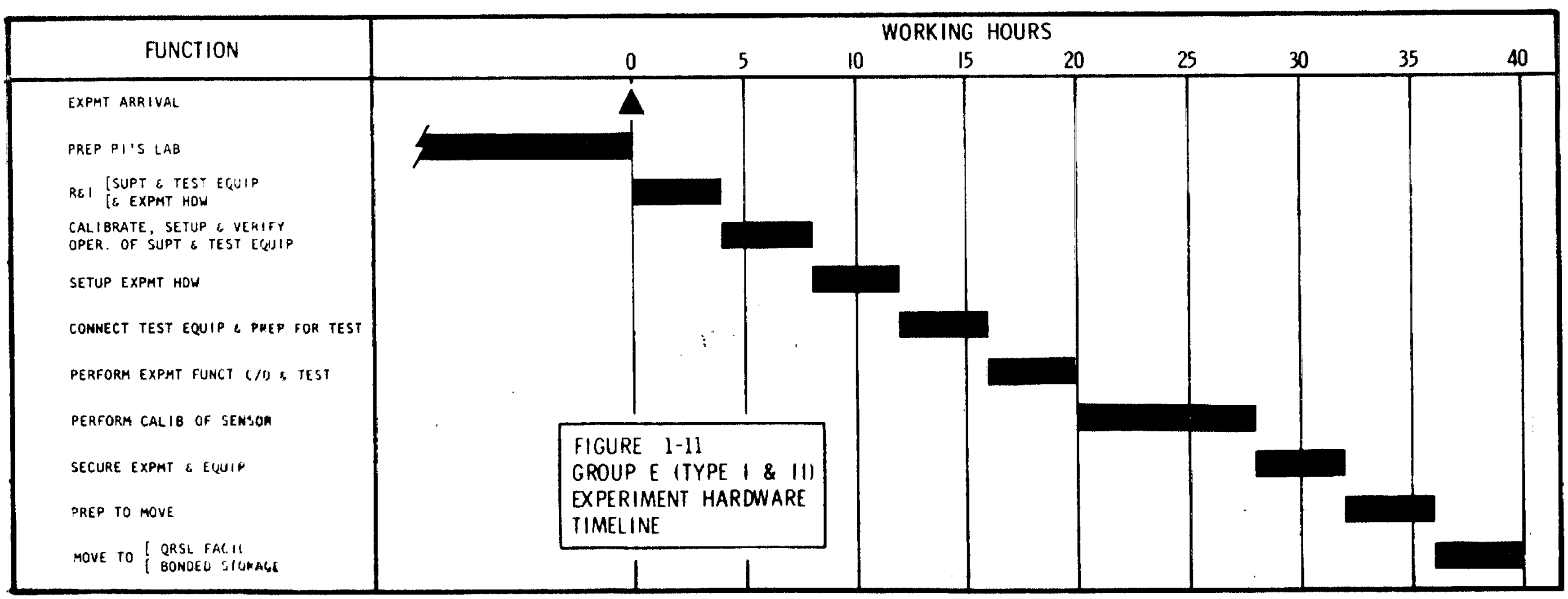

FIGURE 1-11
GROUP E (TYPE I & II)
EXPERIMENT HARDWARE
TIMELINE

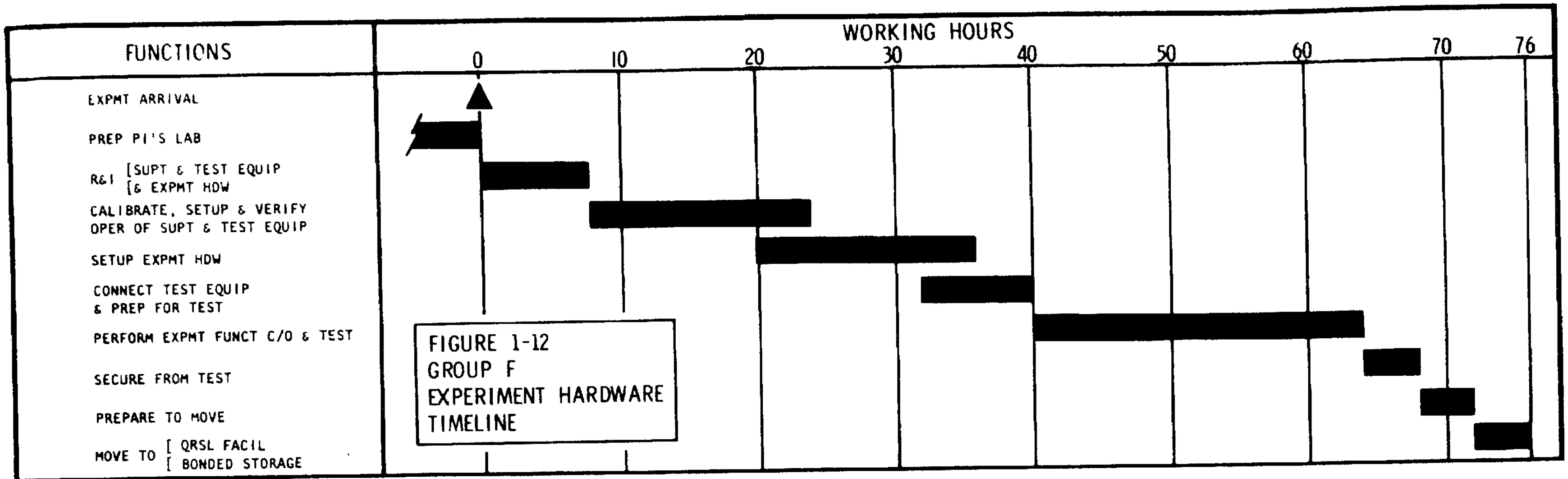

FIGURE 1-12
GROUP F
EXPERIMENT HARDWARE
TIMELINE

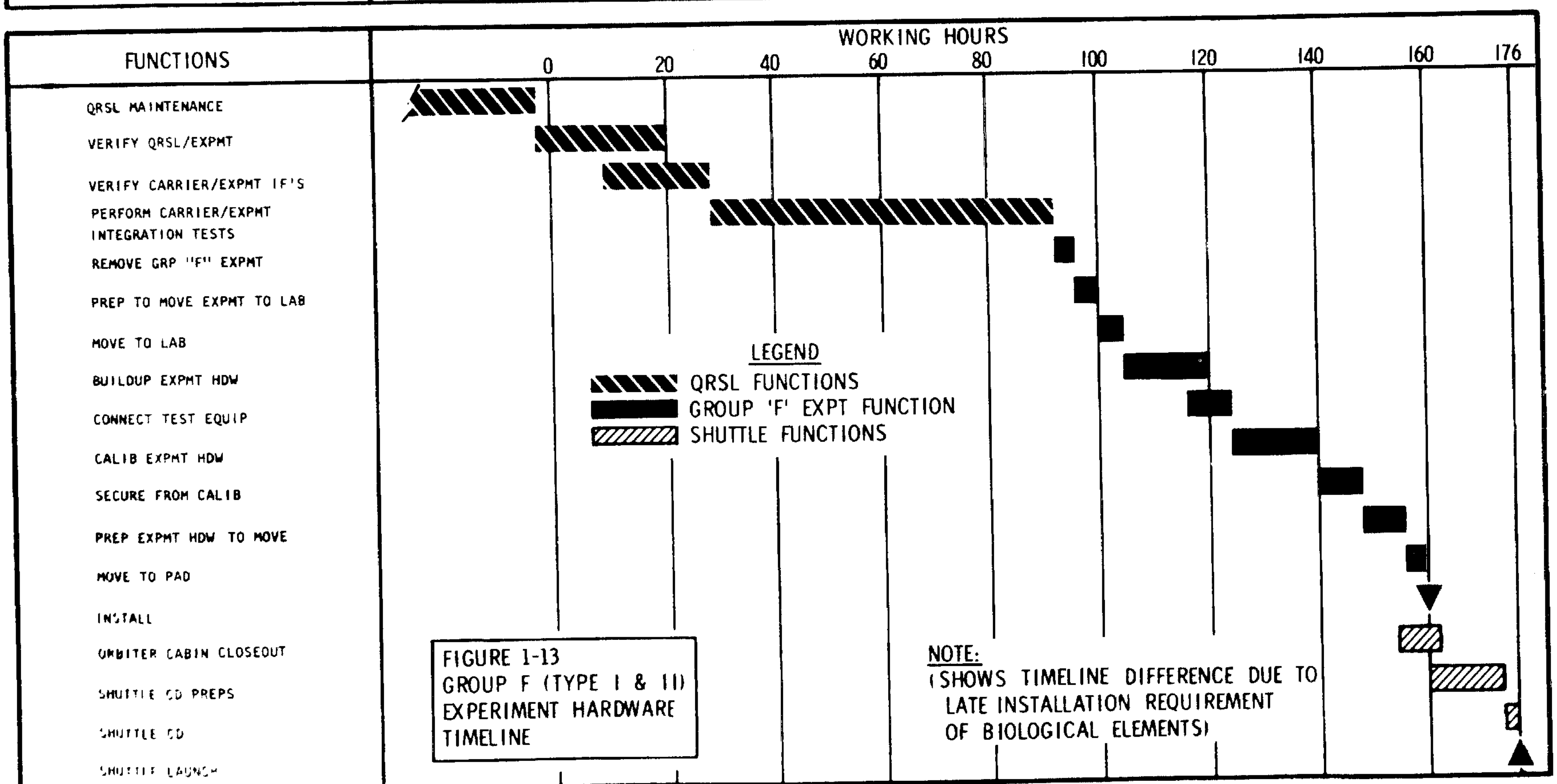

FIGURE 1-13
GROUP F (TYPE I & II)
EXPERIMENT HARDWARE
TIMELINE

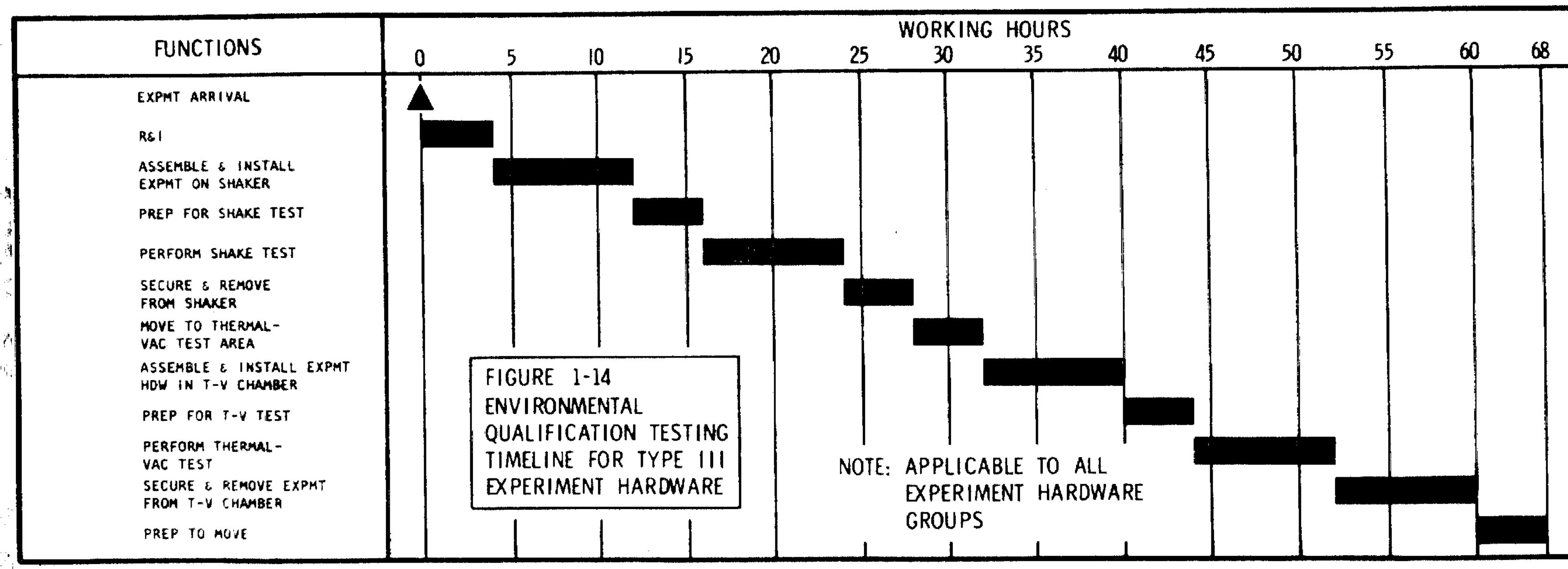

FIGURE 1-14
ENVIRONMENTAL QUALIFICATION TESTING TIMELINE FOR TYPE III EXPERIMENT HARDWARE

4.2.1 Experiment Ground Operations (Cont.)

The Type I and II experiment hardware need not go through this test series since they have either flown satisfactorily before or have been flight certified.

4.2.1.1 Laboratory Preparation

All of the experiment hardware groups require a high degree of cleanliness in the local laboratory as well as temperature and humidity control. Consequently, prior to the arrival of the PI with his experiment hardware, a specific local laboratory is assigned that will satisfy the experiment equipment and sensor requirements. The predelivery activities begin with the necessary physical cleaning of the laboratory interior and the operation of the environmental equipment necessary to establish the environment required by the experiment hardware. In most cases, the environment required is that of a class 100,000 clean room. This activity should be completed before the experiment hardware arrives. Upon arrival, the laboratory is ready to be occupied and the PI can proceed with Receiving-Inspection (R&I) and subsequent operations.

4.2.1.2 Handling and Transportation

The specific handling and transportaiton techniques for the Quick-Reaction experiment hardware depends on the size and weight of each plus other considerations, such as constraints on "g" loading, vibration, environmental control, etc. These considerations will generally be satisfied by the capability of the shipping container plus specific instructions on handling. The size and weight of the experiment hardware varies rather widely within each of the groups. Those that weigh over 75 pounds (see Table 1-4) should be capable of being disassembled for ease of movement or assembled to a framework or fixture that can be moved by a forklift or hoist. The experiments that weigh under 75 pounds are considered "suit-case" types that can be moved about manually by one or two men and easily loaded on and off a truck or cart.

Upon arrival at the launch site, the experiment hardware is moved to its assigned laboratory. The heavier experiment hardware requires cranes, hoists, or forklifts for unloading from the aircraft or other means of transport and a truck or other transportation to the launch site. A crane or other lifting device is also required to lift the heavier hardware and GSE out of their shipping containers in the laboratory in preparation for performing the receiving and inspection tasks.

Many, if not most, of the experiment hardware will arrive at the launch site disassembled. Cleanliness requirements for the experiment hardware is on the order

4.2.1.2 Handling and Transportation (Cont.)

of a class 100,000 clean room in the majority of cases. The experiment hardware can be maintained at this cleanliness level while in the shipping containers and they can then be removed in the laboratory which is also maintained at that level of cleanliness.

4.2.1.3 Receiving and Inspection

Receiving and Inspection functions for all of the experiment hardware are essentially the same. These tasks basically consist of the PI verifying that the experiment hardware and the support and test equipment documentation is complete, and of visually inspecting the experiment hardware. This is performed in the PI's local laboratory where the experiment hardware and sensors are unpacked. Each unit of the experiment hardware, if disassembled for shipment, is given a visual inspection for physical damage. If the units are sensitive to vibration/acceleration, humidity, temperature, or other such constraints, a reading of the monitors supplied for this purpose is recorded. In some instances, a magnifying glass or microscope may be required to perform the visual inspection of the sensors.

4.2.1.4 Pretest, Setup and Calibration

After completion of the receiving-inspection, the experiment hardware and the associated support and test equipment are set up. If the hardware and equipment has been shipped from the PI's home base, it may be necessary to perform verification of calibrations, alignments, connections and other pretest activities including a demonstration of the operational capability of the support equipment.

If the hardware is received in a disassembled state, it is reassembled and electrically connected before performing the checkout operations. To assure proper assembly and connection prior to performing the functional checkout, the electrical interfaces are verified. Power is supplied to the experiment hardware through a fused line to the appropriate connector/pin. The fuse is sized to protect the experiment hardware should the unit be improperly wired or shorted. Successful application of power is followed by voltage and current measurements. This demonstrates that there is a proper return on ground lines. This procedure is performed on all power and power return lines.

In addition, each data line is verified using an oscilloscope. The experiment sensor is not stimulated unless it is necessary to obtain a data output. This operation is strictly qualitative. No attempt is made at this time to analyze data.

4.2.1.4 Pretest, Setup and Calibration (Cont.)

An alternative source of experiment hardware and sensors that may be available to the PI's is the NASA-owned Instrument Bank. This bank contains a variety of sensors, power supplies, amplifiers, magnetic data recorders and other similar flight certified equipment of the kind that is generally used by experimenters. This Bank is primarily intended for those PI's that are equipment or cost limited. Suitable equipment can be checked out of the Bank and assembled together to make up an experiment to fly on a Quick-Reaction Sortie mission. Upon completion of the mission, the PI returns the equipment to the Bank where it is refurbished, maintained as required, functionally checked, calibrated and returned to "stock" for subsequent issue to another PI for use in his experiment.

4.2.1.5 Experiment Hardware Functional Checkout

Upon completion of the support, test equipment, and experiment hardware setup, verification and calibration tasks, preparations are made for the functional checkout activities. These activities essentially consist of the same general sequence of events for all of the experiment hardware groups. The test setup is similar to that for the electrical interface verification, i.e., DC laboratory power supplies, multimeters, oscilloscopes, series fuse boxes, etc. The functional checkout for each experiment hardware group comprises the measurement of turn-on transients (for EMI baseline), steady state current measurements, baseline noise level on data lines which might be induced by electronics with sensors covered or unstimulated, and operational checks of mechanisms such as shutters, film advancers and optical pointing steps. Preliminary mechanical fit checks are performed using templates or master gage plates.

Some PI's may also want to perform software checks using Launch Processing System (LPS) consoles (Volume II, Detailed Technical Report).

In addition to these general functions, each experiment hardware group has certain special considerations that must be addressed. These are discussed below:

- Group A: Group A experiment hardware consists basically of cameras with some kind of an accessory optical system. In most instances the optical system is a telescope. The experiment hardware that falls into this group requires optical benches, an optics laboratory, a camera maintenance/repair laboratory and a dark room for loading film packs and developing film. The PI's locally assigned laboratory must be a class 100,000 clean room per Federal Standard 209 with the necessary airlocks for equipment and personnel. Environmental control is required to provide temperature and humidity control to 73°F ± 3°F and 50% relative humidity maximum. Provisions for a GN_2 purge capability and a vacuum source must also be furnished.

4.2.1.5 Experiment Hardware Functional Checkout (Cont.)

- Group B: The Group B experiment hardware consists primarily of electromagnetic spectrum sensors. There are also optical systems such as mirrors and lenses for focusing light. For this group of experiment hardware, the PI's also require optical benches and a laboratory for alignment of optics. A class 100,000 clean room with entry and exit airlocks is also required for this laboratory. Environmental control is required to the same level as that for the Group A laboratories. For infrared (IR) sensors included in this group, a requirement exists for cryogenic cooling of the sensor.

- Group C: This experiment hardware consists basically of electrostatic field sensors and magnetic field sensors. Care must be taken during the checkout of this hardware to limit and control sources of interference that could result in misleading data readouts. The environmental requirements for this group is designated as "moderate". Lacking definitive data on the meaning of "moderate", it is assumed to be equivalent to the average environmental control found in offices. More specifically, temperature control is provided to 73°F ± 5°F and relative humidity of 50% to 60%. Air filtration is obtained by the use of standard throwaway type filters.

- Group D: The Group D hardware consists of those that receive radio frequency (RF). This includes microwave, L-band, and S-band RF. During the checkout of this hardware,controlled RF stimuli is supplied to the sensors and the resultant operation is recorded and reviewed to verify proper operation. An RF screen room is required to limit and control extraneous RF signals that may interfere with the test operations. Enviornmental conditions required for this group is designated as "moderate". Cryogenic cooling is required for some hardware. The alignment of the antennas requires the capability of boresignting and alignment to an accuracy of ± 1/2 degree.

- Group E: The Group E experiments are ambient environment sensing devices. Most of the experiment hardware for these sensors require electrical power and some have mechanical movements that perform functions such as opening small doors or lids of the experiment containers. Checkout of some of these experiments is potentially dangerous due to the presence of radiation sources necessary to verify sensor operation. During checkout, steps are required to prevent uncontrolled or nearby radiation sources from interfering with the test operations or from influencing the data measurements and calibrations. In some cases, test operations are not performed on the Group E experiment hardware at all because exposing the sensor to a stimulus is actually performing the experiment. Exposing these sensors during a test requires that they be replaced before flight. The primary test of these sensors consists of verifying that they are adequately shielded and protected from radiation sources during the storage period prior to launch.

- Group F: This experiment group is made up of biological experiments of various kinds. Each of these experiments utilizes some living organism ranging from such things as vinegar gnats to specimens of human tissue. Experiment performance consists primarily of determining the effects of the space environment upon the biological specimen. Because of these biological elements, the ground checkout must be conducted very carefully to prevent damage to the specimens.

4.2.1.5 Experiment Hardware Functional Checkout (Cont.)

In many instances the biological element will be included in the testing for only a short period of time, if at all. Then it will be returned to the Biological Lab for safekeeping, calibration, preparation and eventual installation late in the Shuttle countdown on the pad. Ground checkout will primarily verify the operation of the various mechanisms that are used to manipulate, feed, measure, or handle the specimen. Care must be taken to protect the specimens from outside contaminants. It is anticipated that a "control" experiment will be performed on the ground in the PI's local lab concurrently with the experiment being performed in space. This is done to enable identification of those experiment results that are attributable to the space environment.

4.2.1.6 Experiment Sensor Calibration

After completion of the functional checkout of the experiment hardware, it is necessary to reestablish the calibration of the experiment sensors. This is performed on the experiment sensors in each experiment group except for certain of the Group E experiment sensors mentioned previously. Optical experiments, such as telescopes, are boresighted and aligned to their subunits (camera, electronic package, etc.). This alignment is performed using a theodolite and benchmarks or by optimizing the data output when stimulating the sensor. After alignment, the experiment sensor is operated over the expected range of operation by stimulating the sensor. The data output is recorded (film, magnetic tape, etc.) and analyzed to assure that the instrument calibration is acceptable for flight.

4.2.1.7 Move to Quick-Reaction Sortie Lab Area

Upon completing the experiment hardware checkout and sensor calibration, the test equipment is secured, disconnected, and readied for movement to the Quick-Reaction Sortie Lab test area where it is installed in its assigned position in the Sortie Lab.

4.2.1.8 Postflight Experiment Operations

Postflight operations begin with the landing of the Orbiter. After landing, the Orbiter taxis to the safing area where it is allowed to cool, residual propellants are drained, high pressure gases are vented, and the vehicle is generally made safe. The flight crew and the passengers are unloaded at this time as is any time-critical data and experiment components.

Upon completion of Orbiter safing, it is towed to the Orbiter Maintenance and Checkout Facility (MCF) where the Quick-Reaction Sortie Lab payload is removed from the payload bay and placed on its transporter. It is then moved to the Quick-Reaction Sortie Lab Maintenance and Test Facility, where the experiment hardware

4.2.1.8 Postflight Experiment Operations (Cont.)

was initially installed in the carrier. With the carrier in a clean room environment, the experiment hardware is removed and turned over to the responsible PI's who, in turn, take it to their respective local laboratories. Base support is required in developing the film and reducing and separating previously telemetered data to magnetic tape copies, strip charts or data printouts for the various PI's. Upon completion of these activities the PI's, or their representatives, return borrowed equipment, sensors, tools, etc. and prepare their experiment hardware and equipment for shipment to their home base.

It is anticipated that the laboratories used by the PI's on this just completed mission are already assigned to new PI's bringing new experiments to be flown on the shuttle. Some sharing of lab space is necessary during this time interval.

4.2.2 Quick-Reaction Sortie Lab Ground Operations

The Quick-Reaction Sortie Laboratory (QRSL) is a man-tended, pressurized experiment carrier with an attached structural pallet for exterior mounted experiment hardware. The pallet is an unpressurized, structural platform for experiment hardware that does not require manned access but does need direct contact with the space environment. The ground operations for the QRSL are described in the following sections. A timeline flow diagram is included for these operations. This top level flow diagram is synthesized to establish the functional sequence and time requirement as the QRSL is processed through the launch site. The only R&D elements involved in the QRSL ground operations are the experiments. The QRSL is an operational vehicle, however, it is subject to operational configuration adjustments on each mission to accommodate experiment-peculiar requirements.

For the Quick-Reaction Sortie mission concept, several independent experiments are installed on the QRSL. They are scheduled for installation in a specific sequence dependent upon their location in or on the QRSL, access requirements, or other experiment hardware peculiar requirements. The activities involved in the experiment hardware installation, checkout, and integration are discussed in subsequent sections. For the QRSL in the operational mode, ground operations begin with the return of the Orbiter to the launch site and proceed through the QRSL turnaround operations, installation into an Orbiter and launch.

4.2.2.1 Quick-Reaction Sortie Laboratory Description

The QRSL consists of a pressurized, manned laboratory section and an unpressurized, open structural platform. The pressurized section contains crew

4.2.2.1 Quick-Reaction Sortie Laboratory Description (Cont.)

access and experiment airlocks, equipment mounting racks, viewing ports, work bench and stable instrument platforms for use by the experimenters. In addition, certain peculiar experiments will require the QRSL to have optical windows, deployable booms, docking mechanisms, and additional stable platforms. A longitudinal floor is provided in the QRSL which is compatible with the access airlocks. The floor provides space for accommodating the experiment hardware and the experiment support equipment. Consoles are provided for the crew stations, data management, and experiment electronics. SL subsystems are:

- Structure
  - 20 ft. length sidewalls/insulation/thermal radiator
  - conical bulkheads with hatches designed for deployment, docking, and equipment installation
  - single deck longitudinal floor
  - sidewall ports with hatches
  - internal equipment rack installation, wall mounting provisions
  - fluid stores, cryogenic O_2/H_2, HP GN_2, H_2O tanks
- Electrical Power
  - two fuel cells, cryo reactants, and distribution system
- Atmospheric Supply and Control
  - cryo O_2 and N_2
- Atmospheric Purification and Control
  - LiOH/filters
- Thermal Control
  - water/freon loop, cold plates, and radiator
- Data Management
  - two tape decks, processors with memory, input and output buffers, interface units
- Controls and Displays
  - two experiment flight system consoles

Interfaces with the Orbiter include:

- crew
- power
- data/communications
- stability and control
- habitability
- deployment (if required)

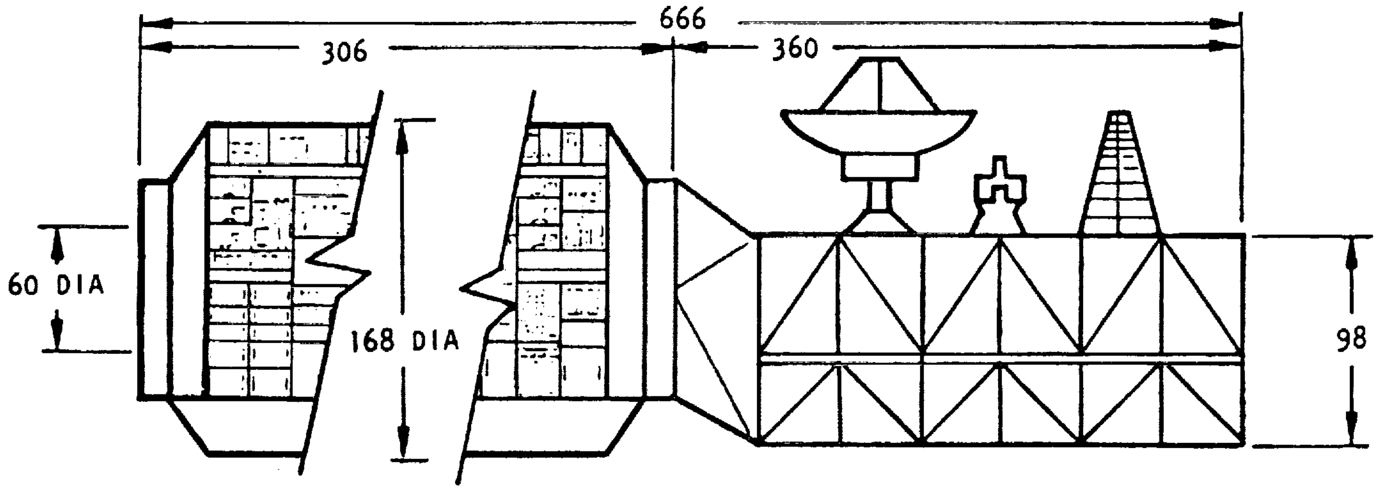

FIGURE 1-15. QUICK-REACTION SORTIE LABORATORY

4.2.2.1 Quick-Reaction Sortie Laboratory Description (Cont.)

The overall length of the QRSL is approximately 670 inches (see Figure 1-15). The pressurized portion of the QRSL is 306 inches. A structural design feature of the QRSL pressure shell allows the carrier to be built also in a shorter configuration. This configuration will provide a carrier with a pressurized section of 186 inches which is approximately one-half the volume of the standard laboratory. This short laboratory has the same systems and equipment as the standard laboratory, consequently, very little volume remains for experiments inside the pressurized shell.

Because the ground operations requirements for the short laboratory are essentially the same as for the standard laboratory, they are not described in this report.

4.2.2.2 Quick-Reaction Sortie Lab Functional Flow

A ground rule for this study is that the QRSL for the Quick-Reaction Sortie Program is assigned to and located at the launch site. Because of the nature of the Quick-Reaction sortie operations, operational configuration adjustments may be required to accommodate some of the sortie experiment hardware. In addition, the QRSL requires maintenance after completing a sortie mission. As a result, the QRSL flow diagram (Figure 1-16) indicates that it is processed through the inspection and maintenance activity before the experiments are installed. During this period of time, all subsystems on board the QRSL are functionally tested, validated, and verified to be flight ready. These tests include end-to-end checks of all wiring harnesses, verification of experiment hardware connector pin assignments, operating

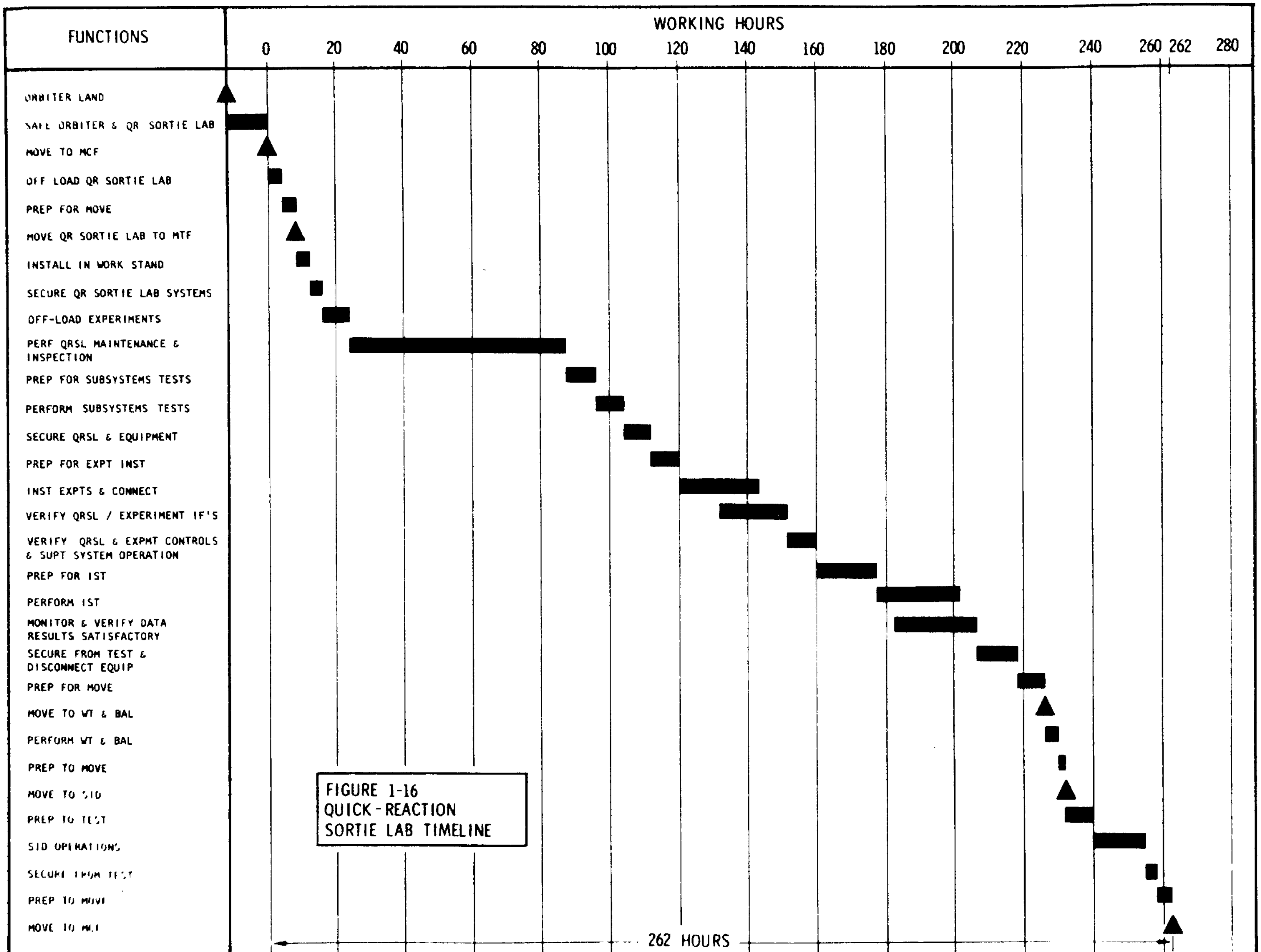

FIGURE 1-16
QUICK-REACTION
SORTIE LAB TIMELINE

4.2.2.2 Quick-Reaction Sortie Lab Functional Flow (Cont.)

tests of mechanical latches and fasteners, and verification of experiment hardware mechanical and electrical interfaces. Test and checkout of the QRSL subsystems can be quite complex because of the life support and other subsystems that provide the crew with a shirt-sleeve environment during experiment operation and other crew related functions in space. When these checks are completed the QRSL is prepared for installation of the experiment hardware.

The ground operations sequence commences with the return of the Orbiter with the QRSL on board. Nominal ground operations require that, after landing, the Orbiter proceeds to the safing area for deservicing and safing. The QRSL subsystems are also deserviced at this time. The cryotanks and fuel cells are drained and vented and the high pressure GN_2 tanks vented. All QRSL subsystems are safed and secured and, in addition, all time sensitive experiment hardware and experiment data is removed at this time.

Upon completion of these activities, the Orbiter is towed to the Orbiter Maintenance and Checkout Facility (MCF) where the QRSL is off-loaded and placed on a transporter and prepared for movement to the Quick-Reaction Sortie Lab Maintenance and Test Facility (MTF). Measures are necessary to protect the QRSL from contamination prior to leaving the MCF.

Prior to entering the MTF, the QRSL and transporter are cleaned externally to remove contaminants picked up during transit. This is necessary to enhance maintaining the clean environment within the facility. The QRSL is then removed from its transporter and placed in the Maintenance and Test Stand. Access platforms are placed in position and the hatches are removed to provide entry into the QRSL. The QRSL subsystems are secured and verified to be safe prior to equipment and/or experiment hardware removal. System configuration is also established and verified at this time. Experiment hardware and supporting electronics/software are then off-loaded. Experiment peculiar electrical and mechanical harnesses are also removed from the QRSL at this time. These items are dispositioned in accordance with established procedures.

After removing all of the experiment hardware and experiment related equipment, inspection and maintenance activities are performed. A thorough inspection of the QRSL is undertaken. This encompasses a structural inspection using nondestructive testing and a meteroid penetration determination. Other subsystems are inspected for operational integrity.

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4.2.2.2 Quick-Reaction Sortie Lab Functional Flow (Cont.)

The QRSL is maintained and modified as needed to accommodate the next scheduled mission. Hatch seals are replaced, mounting plates installed, electrical and fluid harnesses installed, filters, etc. are replaced. Continuity checks and leak checks are performed on the newly installed electrical and fluid harnesses. This activity prepares the complete QRSL for its next mission.

After completion of the maintenance and modification activities, the necessary support systems and equipment are connected and the QRSL is prepared for overall subsystems verification tests. The electrical and thermal loads and the orbital pressure differentials are simulated to verify the integrity of the manned section. Upon completion of subsystems testing, the QRSL is secured and preparations are made for the experiment hardware installation.

As each experiment hardware package is mechanically attached, an electrical bonding check is performed. This is necessary to assure that an adequate and common ground exists between the experiment hardware and the QRSL. Next, the electrical and mechanical connections between the QRSL and the experiment are made. Experiment hardware installation is estimated to take approximately half a day per experiment because of the restricted access inside. The overall time estimate is dependent upon the number of experiment packages to be flown and also the size and complexity of each.

The integration of the QRSL and the experiment hardware is accomplished by performing an Integrated System Test (IST). The Sortie Lab subsystems are energized. The fuel cells are bypassed and a ground electrical source tied into the electrical buss to simulate the fuel cell output. Other subsystems may be simulated in a like manner. Using the on-board control panels and inter-connections, power is applied to each experiment package. The QRSL electrical buss parameters are monitored to detect the presence of any conducted interference. With power applied to all experiment hardware, each is cycled "off-on" to determine whether or not any interference or noise occurs on the QRSL data lines. This information is recorded and later reduced and analyzed. The instrumentation monitors the critical data parameters such as current, voltage, temperatures, etc. during this integration test. As indicated in Volume II of the Detailed Technical Report, much of the monitoring will be achieved using the Launch Processing System (LPS).

It is not necessarily the purpose of this test to demonstrate the actual operation of the experiments and perform a complete check of them. The intention here is to assure that they are compatible with each other and with the QRSL and

2.2.2.2 Quick-Reaction Sortie Lab Functional Flow (Cont.)

to demonstrate, in a broad sense, "GO/NO GO" experiment and QRSL flight readiness. A data line noise level analysis is performed post-test from the test recordings to check for system degradation when compared to earlier baseline noise levels.

After completion of this experiment QRSL integration test, but before securing and disconnecting the test equipment, the data is analyzed to assure that all systems are flight ready. When the analysis is completed, the test equipment is secured and disconnected. The QRSL with the "ready-to-fly" experiments is then moved to a weight and balance area where the total dry weight of the loaded QRSL is determined and the mass center of gravity is determined.

The QRSL is now prepared for movement to and installation in the Shuttle Integration Device (SID).

4.2.2.3 Payload/Shuttle Integration Tests

The QR Sortie Lab is moved to the SID and installed in preparation for performing the Payload/Shuttle Integration Test. This test demonstrates the compatibility between the QRSL, the experiments and the simulated Orbiter systems. In addition, this is a final readiness check for the payloads. This test is also used as a means of further familiarizing the flight Mission Specialists with the operation of the experiments if their complexity requires it. This test is not envisioned as a full-up test to duplicate the actual flight operations, however, it may be required. The basic intent is to validate the various electrical, mechanical, and software interfaces between the carrier and the Orbiter to verify the "GO" or "NO GO" status of the sortie payload.

Upon satisfactory completion of the SID testing, the QRSL is secured, removed and prepared for moving to the MCF for installation in the Orbiter.

The QRSL is placed on its transporter, environmental protective covers are installed, and the support equipment for cooling and purging is attached. It is then towed to the MCF. Preventive measures are necessary to protect the experiments and QRSL from contamination during the loading operation into the Orbiter.

4.3 SHUTTLE GROUND OPERATIONS

The Shuttle ground operations that relate to the Quick-Reaction Sortie Lab experiment payloads are basically those of the Orbiter stage only since it is the payload carrying element of the Shuttle vehicle. Consequently, the other Shuttle elements, the solid Boosters and the HO Tank, are only briefly mentioned.

Nominally the Orbiter used for the Quick-Reaction Sortie mission is one that has returned from an earlier mission and is processed through the standard operational refurbishment activities. This is based on the KSC waterfall chart for Space Shuttle Processing dated 4 May 1972 (Figure 1-17). The payload installation takes place while the Orbiter is in a horizontal position, resting on the landing gear in the MCF. This chart indicates that at plus 80 working hours, one calendar day (12 hours) is scheduled for the entire payload operation. This time interval is divided into 8 hours for loading and verifying the payload to Orbiter interfaces and four hours for preliminary servicing of the payload. For this study, it is assumed that the time interval allowed for payload loading and servicing is adequate.

After completion of payload installation and interface verifications, the Oribiter payload bay doors are closed and secured and the Orbiter is moved to the Vertical Assembly Building (VAB) high bay No. 4. Erection slings are attached to the Orbiter. It is lifted and rotated to a vertical position using the overhead bridge crane. It is then transferred into VAB high bay No. 3 where it is mated to the vertical SRM boosters and Orbiter HO tank. These elements were assembled earlier on the Mobile Launcher (ML) in this bay.

With the Shuttle fully assembled, the entire vehicle is checked out and interfaces verified. Leak checks are performed and prepower-on inspections are made. Shuttle electrical power is turned on and power-on tests are performed. The various items of ordnance required for flight are installed, checked out and safed. After satisfactory completion of all testing, preparations are made to move the Shuttle to the launch pad.

The ML with the Shuttle is moved from the VAB to the launch pad and the necessary connections to the pad are made and verified. Shuttle electrical power is again applied and a quick verification test is performed to verify the flight readiness of all systems. At this time, the Quick-Reaction Sortie experiments are checked for the last time to verify their status. In addition, there are certain Group F biological experiment elements that must be installed during the precount. Installation takes place at this time. A quick review of the test data is performed including data from the experiments. If any experiment fails or major discrepencies appear now, it is not likely the experiment will be repaired or replaced

4.3 SHUTTLE GROUND OPERATIONS (Cont.)

because of the nearness to launch. The failed or inoperable experiment is flown inoperative and returned with the others. Later, it can be repaired and prepared to fly, if desired, on another sortie mission.

When all testing and verifications are completed, the cabin closeout and final cargo servicing operations are completed and countdown preparations are begun for launching the Shuttle within a few hours.

FOLDOUT FRAME 1.

FOLDOUT FRAME 2

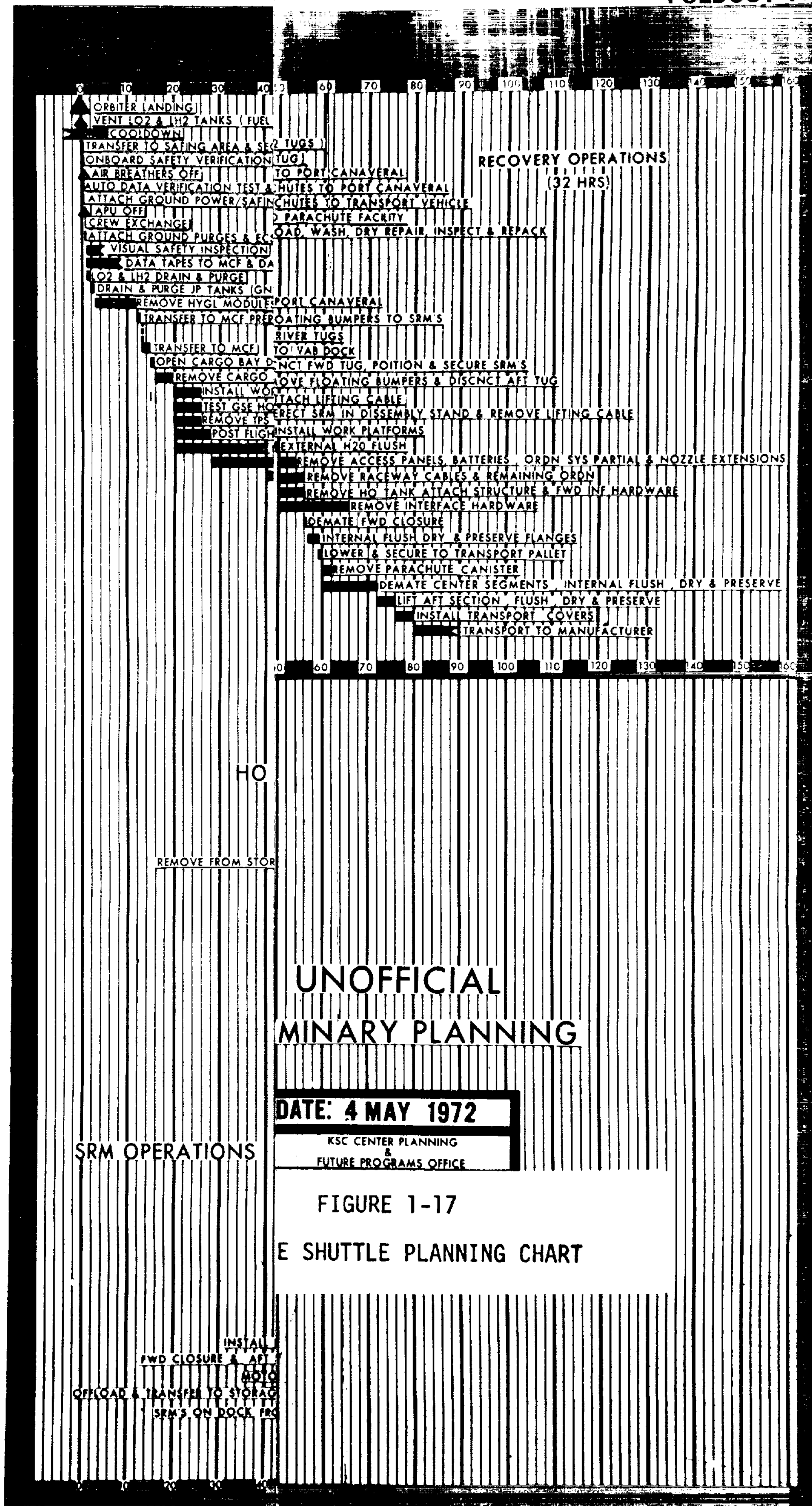

FIGURE 1-17

E SHUTTLE PLANNING CHART

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SECTION 5 - INTERFACE ASSESSMENT

5.1 ASSESSMENT OF THE NEED FOR A PAYLOAD INTEGRATION MOCKUP AND A SHUTTLE INTEGRATION DEVICE

The Space Shuttle provides a new payload support concept which reduces or eliminates many of the restrictions and constraints affecting previous programs. Such a concept reaches an optimum only if all related hardware, operations, and interfaces are effectively planned and integrated. To realize this goal, the operational aspects relative to payloads must be developed which translate the inherent capabilities of the Shuttle into a practical program.

Present requirements for the Shuttle call for an Orbiter with a 15 by 60 foot payload bay which can handle weights up to 65,000 pounds. A wide variety of potential payloads include satellites, space station modules, research and applications modules, cargo modules, personnel carriers and propulsive rocket stages. The wide variance in the type of cargo accordingly means that a wide variance in capabilities of the ground systems are required.

A primary goal of the Shuttle Program is a quick-turnaround of the Orbiter stage for another mission. All Shuttle and payload operations must be oriented toward achieving this goal. In the specific area of payloads, there are several approaches that can be used in preparing them for flight, not all of which are capable of reaching this goal. These approaches are:

- Extend the turnaround time for the Shuttle to accommodate slower payload operations.
- Install payloads without integration and verification testing, depending on humanly correct execution of systems design construction, and assembly.
- Complete integration and verification of payload to Orbiter interfaces and system operation prior to installation in the payload bay.

In the interests of safety, compatibility and mission success, the last approach is the only one that is considered in this analysis.

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5.2 PIM ANALYSIS

A Payload Integration Mockup (PIM) is considered to be an operating replica of the payload on a specific mission. It is established and maintained on the ground to support the orbital mission operations as well as other functions. This support is provided in the areas of:

- Configuration Control
- Fault Isolation
- Physical/Functional Integration
- Training
- Mission Control Interfaces
- Maintenance Plans and Procedures

The selection criteria used to determine whether a PIM is needed or not is established by analysis of the payload requirements. Generally, to be a PIM candidate, a payload should have one or more of the following characteristics:

- Long term operation
- Not readily returned for update
- High in cost relative to PIM construction and maintenance costs
- Compatible with manned operation or maintenance

Therefore, for each payload, a separate PIM is required. Based on this, it is apparent that the Quick-Reaction Sortie Lab experiment payloads do not meet this criteria primarily because the mission duration is short (7 days) and they are low in cost. Consequently, a PIM is not considered necessary for the Sortie Lab and the experiments.

5.3 SID ANALYSIS

The Shuttle Integration Device (SID) concept was developed to help resolve the problem of integrating and verifying Shuttle payloads. Relatively short Orbiter turnaround schedules, by necessity, allow only minimum time for payload installation and checkout. Some multidiscipline payloads could have compatibility and interference problems which could require weeks to isolate and correct. The use of an operational Orbiter as a payload test-bed is unjustified when schedules, costs, and safety factors are considered. Consequently, it is desirable to verify the integrated operation and compatibility of payload hardware, software, and flight equipment prior to installing the payload in the Orbiter to ensure meeting Shuttle turnaround schedules. Compatibility with other payload instruments must also be checked to provide some assurance of a high degree of mission success.

As a result of this analysis, it is concluded that a Shuttle Integration Device is necessary for the Quick-Reaction Sortie Lab to use before it is loaded into the Orbiter. This SID must meet minimum but realistic integration requirements by providing:

- a physical replica of Orbiter structures and equipment that directly interface with payload equipment and
- a functional replica of payload interfacing flight systems.

The SID presents a physical replica of the Orbiter hardware interfaces to the QRSL. These include mounting hardware and interface hardware such as electrical cables and fluid lines. It also provides the capability of verifying payload alignment with the Orbiter attachment points. The functional capability of the SID includes duplicating or simulating the interfacing electrical and electronics systems and the software with the mission specialists station controls and displays and with the Orbiter computer.

The capabilities of the SID must be developed to furnish a complete, verified, flight-ready payload. These capabilities must be based on the Orbiter flight configuration relative to the Quick-Reaction Sortie Lab experiments.

The SID capabilities should include as a minimum the following:

- Accept for verification all Quick-Reaction Sortie Lab payloads
- Provide simulated Orbiter support, i.e., electric power, gases, environmental control, etc.
- Provide an integrated Orbiter/payload software program to operate the Quick-Reaction payloads
- Provide simulated Orbiter checkout and monitoring of payloads
- Verify compatibility of payload to Orbiter interfaces
- Maintain cleanliness levels compatible with payload requirements
- Provide input to Orbiter weight and balance and CG data for the flight-ready payload system
- Verify compliance with safety specifications

Utilizing a SID for the Quick-Reaction Sortie Lab payloads will result in:

- Development of a complete, integrated, verified payload system on a timely basis

5.3 SID ANALYSIS (Cont.)

- Lower support costs by minimizing the quantity of unique hardware
- Test results that can be correlated by the eliminating the error of unique hardware operators
- Standardized tests
- Standardized training since equipment is identical
- A controlled data source for trend analysis, calibration data, and failure analysis
- A high degree of confidence that Orbiter safety is not compromised and that experiment operational requirements are adequately provided
- Early identification of problems that if not found until after installation in the Orbiter could impact the entire Shuttle flight schedule

There are several alternative approaches to utilizing a SID. These include:

- Increase the Shuttle turnaround time to provide for contingencies and corrective repairs and test time
- Use an Orbiter for the integration device
- Use physical interface simulation only and ignore the functional verification of the interfaces
- Accept a higher risk of safety and operations by installing the payload directly into the Orbiter

None of these alternatives provide the degree of confidence in the integrated QR Sortie Lab/Orbiter operations that a SID will and that TRW believes is necessary with regard to the Orbiter safety and compatibility of the payload with the Orbiter. In addition, some of the alternatives seriously affect the targeted Shuttle flight schedules with the 10 working day or two weeks turnaround requirement.

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SECTION 6 - OTHER REQUIREMENTS AND FACTORS

6.1 FACTORS RELATED TO FOREIGN, DOD, AND COMMERICAL PAYLOADS

In assessing the potential impact on the launch site Quick-Reaction integration activity due to the integration of experiments developed by foreign, DOD, or commercial interests a basic assumption was made. Specifically, the constraints and requirements imposed for the QR program will apply equally and to the same extent to foreign, DOD, and commercial users.

6.1.1 Foreign

One of the many possible benefits of the Space Shuttle Program is the opportunity for participation by foreign nations in space experimentation. In particular, the possibility for the "emerging nations" to share in the space exploration and earth observation from space. One way that such countries could participate in a mission is through the Quick-Reaction Sortie Mission. A particular instrument could be developed or modified by the foreign country and delivered to the launch site for integration with other instruments, both domestic and foreign, on a Sortie mission. The individual instrument packages could include small deployable satellites which would have "small nation identity". TRW personnel exposure to the Latin American countries left the impression that the emerging nations want to be identified with a space program. To have flown an instrument or launched a small satellite via the Shuttle would be very meaningful to emerging nations such as Argentina, Brazil, India, Spain and many others. The integration assessment of foreign payloads performed under the MCC study contract NAS10-7685 assumed payloads from the developed nations such as England, Germany, France, Italy, etc. In this assessment of the integration of foreign payloads, it is assumed that this may include these countries in the "emerging nation" political-economic category. With this assumption, the assessment of integration at the launch site of foreign payloads deserves a more thorough treatment.

6.1.1.1 Program Management

The political instability which typifies many of the emerging nations may hinder any long-term project because of halts in funding, changes in priorities,

6.1.1.1 Program Management (Cont.)

internal political crises, and related problems attributable to bureaucratic politics.

6.1.1.2 Engineering Competence

The engineers and scientists of the emerging nations are typically well trained in the academic disciplines and many obtained their higher education in the U.S. or the European power countries. They typically, however, do not have experience in dealing with the practical problems of fabrication and testing. This is compounded by the lack of skilled technicians and production level people.

6.1.1.3 Product Integrity

Foreign emerging nations usually buy commerical parts (transistors, resistors, capacitors, integrated circuits, etc.) rather than MIL Specification parts or space-rated parts that have passed qualification tests. The fabrication and assembly methods may be less formal than in the U.S. and quality control programs may be less effective. The net result of these factors is that the integrity of the instrument may not be on a par with an instrument built under NASA or DOD control.

6.1.1.4 Testing

The foreign countries discussed herein typically do not have the testing facilities available in the U.S. or western Europe, therefore the testing, particularly environmental, must be performed in the U.S. or must be an abbreviated form of the test.

6.1.1.5 Net Results

The net result of the aforementioned factors is an extension in the time schedule anticipated for completion of an instrument development. This additional time is attributable to delays due to:

- Management and funding problems
- Fabrication and assembly problems
- Logistics of testing at foreign facilities and test setup delays
- Rework and retesting time due to lower product integrity

6.1.1.6 Effect on Launch Site Integration

The effect of these factors on the launch site integration process is in the delivery time of the particular instrument. Delays in hardware delivery must be anticipated and allowed for in the schedule at the launch site. An obvious

6.1.1.6 Effect on Launch Site Integration (Cont.)

solution to this is to request delivery considerably ahead of normal such that delays in delivery can be absorbed in this schedule margin. Another solution is for the launch site to provide the facilities and assistance for the testing phase of the program, i.e., the foreign agency would bring the instruments to the launch site for environmental testing and final checkout earlier than normal.

6.1.1.7 Summary

In summary, the launch site could perform a valuable service in the testing and integration of foreign payloads, particularly those from nations that have not previously participated in space projects. Some of these services include providing test facilities, test equipment, and performing a role of consultant and adviser on the test and integration of these instruments.

To implement such a service, it must first be established that there will be participation by foreign nations of the category discussed above and that they do indeed desire this type of support. It would be desirable, therefore, that there be a foreign coordinating office, possibly the Office of International Affairs at NASA Headquarters, or a branch of the Shuttle Program Office, whose function would be to recruit and coordinate participation by foreign agencies.

6.1.2 DOD

Generally, DOD experiments are parts of long-term engineering test and development programs, satellites, networks, etc. The hardware comprising these experiments is not significantly different from other NASA payload hardware with respect to operational, test, and/or integration requirements. Thus the potential DOD Quick-Reaction experiments should present no hardware integration problems.

Other DOD requirements, however, may present problems. Of principal concern is security. Classified DOD experiments, will dictate secure checkout areas and strict access control after installation in the carrier. An efficient QR integration activity will operate by having several users and experiments in various stages of checkout and integration at any one time. The QR philosophy would be defeated by limiting access everytime a classified DOD experiment has to be processed. One way around this problem is to allow classified experiments only if DOD is willing to share the integration and checkout facilities without imposing undue constraints on the other users. Another solution would be dedicated DOD facilities either entirely separate or as a portion of the launch site QR facility. Unclassified DOD experiments would present no problems of this nature.

6.1.3 Commercial

The QR concept is very much in line with the desires of commercial interests in several respects. They are generally very cost conscious and hence opposed to the imposition of unnecessary documentation and other detailed requirements such as reliability certifications, test, etc. In essence, their desire is simply to purchase a launch service. The idea of high user involvement and responsibility is particularly suited to their philosophy.

A possible concern might be the handling of what a commercial organization considers proprietary hardware, software, or data. For example, an oil company that has developed a new instrument for geological survey may consider it proprietary. This is not an insurmountable problem as NASA has been handling contractor's proprietary information for many years with no significant problems.

One other factor to be considered is liability. Undoubtedly, some commercial interests will require agreements with respect to experiment hardware damage or loss, delays, and possibly mission compromise.

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SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS

Detailed Technical Report

Volume II

Appendix

SECTION 1 - INTRODUCTION

The purpose of this phase of the study was to develop the Quick-Reaction Sortie Mode Operational Concept based upon the analysis and requirements established in the previous phase.

The Quick-Reaction Operational Concept comprises three basic elements: hardware, software and mission integration.

Hardware integration includes the analysis and design of interface adapter hardware, the installation of the experiment hardware into the Sortie Lab and the subsequent test and checkout operations. These tasks are performed by an "artisan" group, i.e., a small group of highly skilled craftsmen and technicians. A "model shop" approach was taken for hardware fabrication.

Software integration requirements are those necessitating data processing by the SL Data Management System for control and display, downlink, and magnetic tape recording. The integration process begins back at the user's home laboratory. Through the use of the Launch Processing System (LPS), planned for KSC, the user may communicate with the integration site via LPS terminal and develop his software in the proper DMS language. The integration site may, in turn, integrate his software with other experiment software and the DMS.

Mission integration involves the coordination of user's requirements for Orbiter maneuvers with the Shuttle planning activities. This is accomplished by inputting those requirements into the Vehicle Management and Mission Planning System (VMMPS) being developed by MSC.

To illustrate the Quick-Reaction Integration Concept, a typical experiment, one that has flown on the NASA Ames CV-990 aircraft program, was used. In this manner all three elements of the concept, i.e., hardware, software and mission integration, are exercised.

SECTION 2 - ILLUSTRATIVE EXAMPLE

2.1 INTRODUCTION

The AEROPOL infrared polarimeter was built for measurements between 1.1 and 3.5 μ with a 1.5° field-of-view, using a wire-grid polarization analyzer. A lead sulfide (PbS) detector is cooled by condensed Freon-13. The instrument operates under mini-computer control, giving a polarization least-squares solution each 2.5 seconds. AEROPOL was flown on the NASA CV-990 aircraft, in a remote-sensing study of terrestrial cloud particle sizes and shapes.

2.2 INSTRUMENT DESIGN

The following design goals were set for the AEROPOL instrument (a polarimeter measuring aerosols from an aeroplane):

- Operation in the infrared between 1 and 4 μ (necessitated by contamination from molecular scattering at short wavelengths and thermal emission at long wavelengths, and by desire that wavelength be comparable to cloud particle sizes, and that measurements be made in wavelength regions of differing amounts of particle absorption).
- Pointable (in order to vary the scattering geometry, to generate a curve of polarization versus phase angle while tracking a given region).
- Field-of-view less than 2° (to avoid excessive angular smoothing of rainbow peaks, glories, etc.).
- Polarization accuracy ± 1/4% for clouds of intermediate albedo.
- On-line polarization analysis and operational control.
- Photographic record of target.

2.3 OPTICAL

Light from below passes through a 3mm thick protective window of GE125 fused silica and then through a rotating Perkin-Elmer wire-grid polarizer (2880 gold wires/mm deposited on AgBr) forming the entrance pupil of 21.5 mm. The wire grid substrate is significantly wedge-shaped as supplied by the factory (-16 arcminutes in this case); a compensating wedge of 1.0 mm thick Schott IRG9 glass is mounted with this analyzer to minimize displacement of the field-of-view. Maximum image displacement in the focal plane is 0.13 mm.

The objective lens rotates with the wire-grid analyzer. It was cut from crystalline MgF_2 by Continental Optical Co., with the fast axis perpendicular to the optic axis and mounted at 45° to the analyzer principal axis. Thus it serves as a "pseudo-depolarizer" for the highly polarized light incident from the analyzer, with a retardation which varies with wave length and with path length through the lens. The central lens thickness (25.4 mm) is near the minimum value to give sufficient depolarization for the several filter passbands. The success is shown by the low values ($\leq$ 1%) of instrumental polarization found for incident unpolarized radiation. A disadvantage of this analyzer/depolarizing objective lens combination is that the lens has different back focal distances for the ordinary and extra-ordinary rays. This difference (4.9 mm in the present case) was acceptable here because of the relatively large and uniformly illuminated field-of-view. The objective lens is biconvex, $\approx$f/6.8, shaped for minimum spherical aberration.

The converging beam falls on a two-bladed reflective chopper (a single piece of gold-coated plate glass). During the dark phase the light beam falls on a 3M 101-C10 Black Velvet paint surface, while the detector sees itself (the coldest point in the instrument) in a concave spherical gold-coated mirror.

The reflected beam passes through one of five different interference filters, described in Table 2-1. The corresponding effective wave lengths (in this case the "isopolaral" wave lengths λ_{ip}) are given in Table 2-1. The physical thickness of the several filters are tailored to approximately achromatize the focal distance.

Next in sequence is the 4.0 mm focal-plane aperture, restricting the field-of-view to 1.5°, followed by the evacuated dewar, incorporating a sapphire window, a plano-convex silicon Fabry lens, and the PbS detector. The lens images the entrance pupil onto the 0.5 mm x 0.5 mm detector surface; the lens is antireflection coated both sides, and is separated from the detector by 1.85 mm. The Fabry image quality and the instrumental polarization effects are discussed in the Calibration Section. Santa Barbara Research Center supplied the detector-dewar combination, and mounted the lens to specification. The detector alone has a peak D-star at

λ_{peak}	T_{peak}	λ_{ip}	Amplifier Gain
1.27 μ	0.77	1.236 μ*	1
1.64	0.71	1.595	1
2.28	0.72	2.222	1.7
3.18	0.67	3.084	14
3.43	0.75	3.379	21

* Short-pass filter; the silicon Fabry lens forms the short-wavelength side of the passband.

TABLE 2-1. FILTER CHARACTERISTICS

2.8 μ of 4.2×10^{11} cm $Hz^{1/2}$ $watt^{-1}$, when operated at 193°K with a 90 Hz chopping frequency, viewing a 295°K background over 2 π steradians.

For visual tracking a second port is located adjacent to the infrared window. Light passes through a pressure window, then a 90° reflection, through a 1:1 riflescope with reticle, and to a Nizo S-56 super-8 mm single lens reflex movie camera. The resultant field-of-view is 10°. One Kodachrome II film frame is recorded at each rotation of the analyzer for which polarization data is taken.

2.4 MECHANICAL

The basic instrument is a circular cylinder mounted in a 14" "side-looking" window of the NASA CV-990, with an IR window pointing downwards. The entire cylinder can be manually rotated about its axis of symmetry, which is horizontal, to provide views forward and aft over the range ±70° from the nadir. This rotation permits selection of the scattering angle, for a given flight path; alternatively it permits a limited tracking ability for isolated clouds on the flight path. The rotation mechanism employs an outer ball bearing, and uses double O-ring seals of silicone rubber. The pressure differential between interior and exterior is typically 500 millibars, and the air temperature differential is 75°C.

Two motors are employed. A hysteresis-synchronous motor drives the chopper blade at 83 chops per second, and, through a linkage of gears, the analyzer/depolarizer/lens unit at 0.48 seconds per revolution. Stainless steel gears are lubricated with a mixture of machine oil and low temperature grease. A stepper motor drives the filter wheel rotation at 9 milliseconds (msec) per step until the desired filter position is achieved (16 steps between filters). The chopper mirror is readily positioned and checked dynamically by using a stroboscope triggering on the computer sample pulses.

The detector with cold shield and Fabry lens is mounted in a small glass dewar which is potted in a metal can with RTV compounds. A miniature cylindrical Joule-Thompson open-loop cryostat is press fitted into the dewar inner finger with its outlet tube immediately behind the detector platform. A conductive coating on this inner finger serves to electrically ground the liquid coolant spray to the metal cryostat tubing. Freon-13 gas at 225 psi is supplied to the cryostat, with a flow rate of approximately 1 liter per minute. A 25-minute initial cool-down is done at 250 psi. The Freon-13 is dried by filtering it through a 4.4" length of granular molecular seive. An in-line flowmeter is especially useful as an indicator of leaks in the system.

2.5 ELECTRONIC

The electronic system is relatively complicated by the need for on-line reductions. These were necessitated by the exploratory nature of the experiment combined with a flight program limited in duration and the goal of getting the most knowledge from the initial flights. In addition, the instrument had to be made automatic to a great extent to free the observer for manual tracking of the cloud targets. To achieve these goals, and to allow for fast changes if needed during the flights, the system was built around a Data General Corporation NOVA 1200 minicomputer as the instrument controller and data processor.

Figure 2-1 shows a block diagram of the electronic system. The detector bias is adjustable between 0 and 50 V to set the sensitivity of the detector. This voltage is applied across the PbS photoconductive detector wired in series with a 0.6 megohm load resistor, through an RC-network to protect detector from voltage transients. The AC signal from the detector, which is proportional to the incident intensity, is preamplified by an Infrared Industries Model 650A low noise amplifier and then amplified by a programable gain amplifier, the gains of which are set to give approximately equal signals with each of the optical filters for a typical cloud. These gains, which are selected by reed switches at the filter wheel, are shown in Table 2-1.

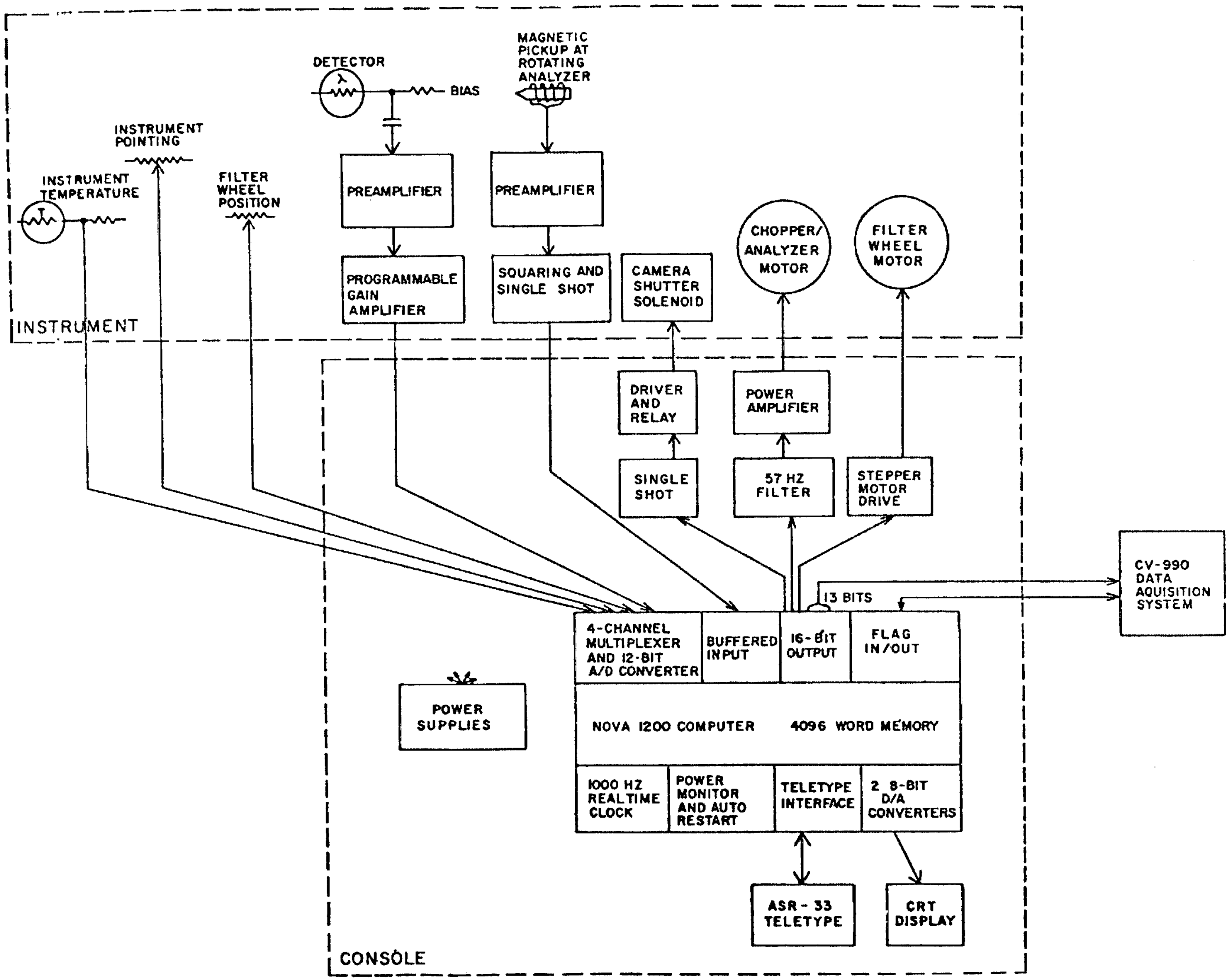

FIGURE 2-1. AEROPOL ELECTRONICS SYSTEM BLOCK DIAGRAM

2.5 ELECTRONIC (Cont.)

The 12-bit analog-to-digital converter has four program selectable inputs. One is used to sample the detector signal synchronously with the light chopper rotation to get a reading during each light and dark position (i.e., one reading each 6 msec.). The other three inputs are used to read the filter wheel position and the instrument pointing angle from the outputs of two precision potentiometers and the temperature inside the instrument from a resistor-thermistor voltage divider.

The position of the rotating polarization analyzer is sensed by a magnetic pick-up which gives a synchronization pulse once every revolution of the analyzer.

All timing is derived from the computer's 1 kHz crystal controlled oscillator. From this and the synchronization pulses, the program creates a 55.56 Hz signal to drive the synchronous chopper/analyzer motor, the filter wheel stepper motor pulses, the camera triggering pulses, and the 1 second pulses to update a 24-hour software clock.

The peripherals include a long persistance oscilloscope used as an X-Y CRT display, and a teletypewriter. The CRT can be switch selected to show the analog detector output, the digitized detector signal fed back from the computer, or the analyzer synchronization signal. Measurement results are punched on paper tape and printed by the teletypewriter, and also recorded on magnetic tape through the NASA CV-990 data acquisition system as a back-up.

Operator input to the system is through the teletypewriter keyboard to set initial clock time and parameters for the automatic measuring sequence, and through the computer sense switches for control of the motors and for start of measurement.

2.6 ON-LINE PROCESSING

The assembly language program for the NOVA computer was created using a cross-assembler running on a large scale CDC 6400 computer. This allowed the use of cards rather than paper tape for the source program which simplified editing and gave the power of a higher level assembler than is available for the NOVA with its 4096-word memory.

The program is approximately 950 statements long. It is loaded in the core twice, together with simple operator controlled routines to reload the program from the copy in case of program trouble and to print out the differences between the two copies for debugging purposes.

A simplified flow chart on the program is shown in Figure 2-2. All timing, input-output and control functions, and the commutation of measured data, are handled by interrupt routines. The background program consists of the updating of the output files.

During a measurement sequence, the filter is automatically changed after a predetermined time of data cumulation. After a sequence of six filters, the results are printed, punched and time-shared with the next measurement sequence.

All calculations are done using integer arithmetic and tables for trigonometry functions. This is possible as the range of the input data was predictable because of the limits of the analog-to-digital converter and allowed the use of appreciably less core memory and faster measurements than with floating point arithmetic.

Each "dark" reading is stored to be subtracted from the following "light" reading, resulting in 40 difference readings corresponding to the 80 samples each revolution of the analyzer. The signal corresponding to a partially linearly polarized input is an offset double sine-curve which can be represented by:

$$S(\theta) = A_o + A_2 \cos 2\theta + B_2 \sin 2\theta$$

where θ is the angle of rotation of the analyzer and A_o, A_2, B_2 are constants dependent on the intensity and polarization of the incoming radiation. The on-line program solves for A_o, A_2, and B_2 by cumulating the difference readings into three storage locations, one representing the cumulative sum of all the differences and the other two the sum of the differences multiplied by the cosines or sines, respectively, of two times the angular position of the analyzer. After a complete measurement at one filter these sums are divided by the total number of samples and the last two sums additionally by 2, i.e., A_o, A_2, and B_2 are solved from:

$$A_o = \frac{1}{n} \sum_{i=1}^{n} D_i$$

$$A_2 = \frac{1}{2n} \sum_{i=1}^{n} D_i \cos 2\theta_i$$

$$B_2 = \frac{1}{2n} \sum_{i=1}^{n} D_i \sin 2\theta_i$$

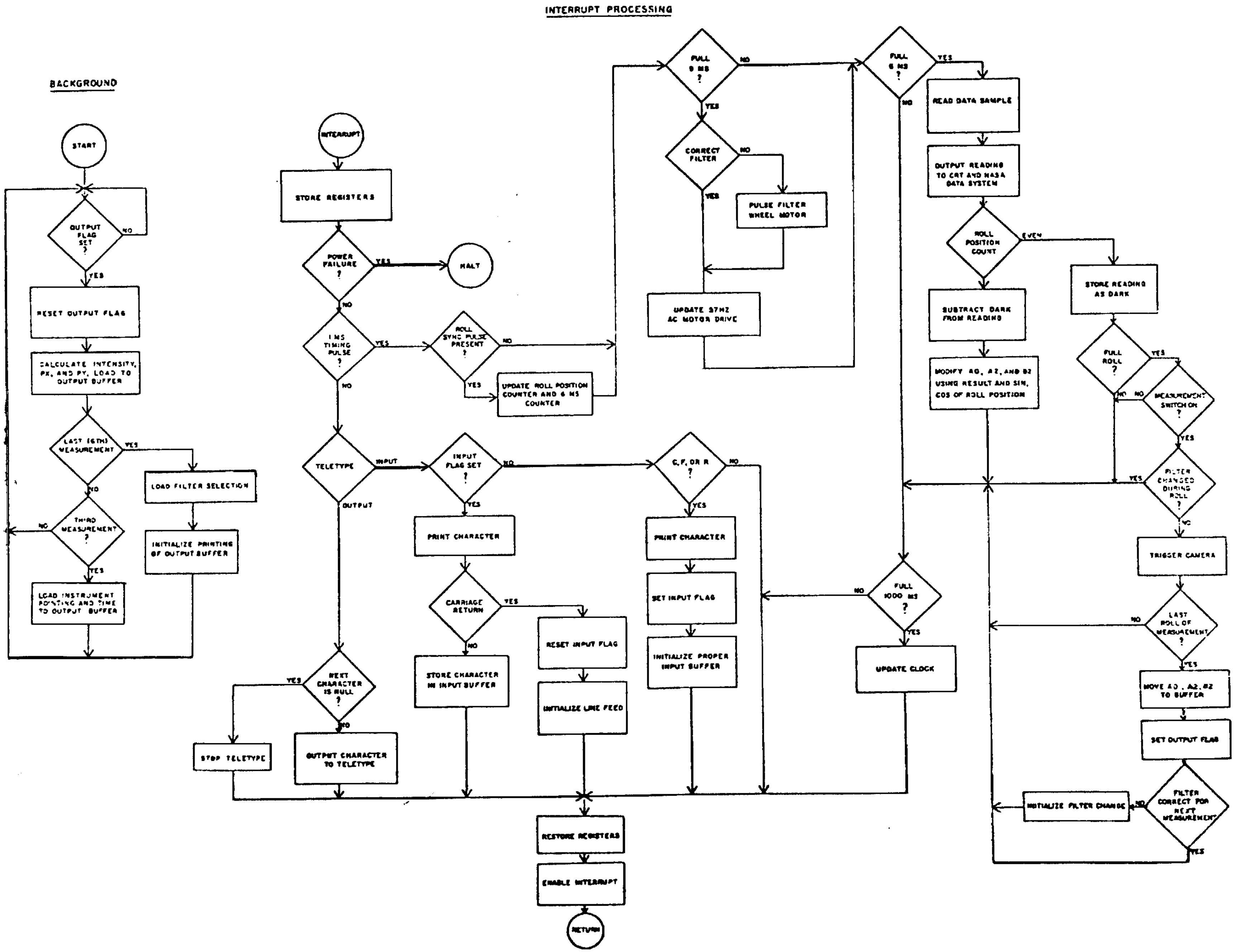

FIGURE 2-2. AEROPOL PROGRAM FLOW CHART

2.6 ON-LINE PROCESSING (Cont.)

A_0 is proportional to the intensity and A_2/A_0 and B_2/A_0 represent the fractional polarization in component form. These are printed out, multiplied by suitable constants to avoid decimal numbers (A_0 by 2 to keep full scale intensity readings somewhat below 10,000 to always limit the output to four digits, each fraction by 1,000 which then represents 100% polarization along one component axis). In addition to these three numbers for each of the six filters, the printout contains local time and a record of operator-selectable parameters.

During off-line processing, data are punched on cards from the paper tape to allow easy editing. Further processing converts all housekeeping data to proper physical units and includes calibration corrections.

2.7 FLIGHT PERFORMANCE

Successful observing runs were made over a wide variety of cloud types during a series of ten airplane flights over the northwest U.S. coast, the central U.S., the Caribbean, and the equatorial western Atlantic.

Some instrument problems were experienced during the initial flights due to unexpectedly high cooling of the instrument by the air flow. The chopper motor was being overloaded and running asynchronously, caused by thickening of the lubricant on a set of helical gears in the drive train. Also an operational amplifier went into oscillation below 0°C. The addition of localized resistive heaters solved both problems.

Other system components worked very well particularly the simple and faultless operation of the open-loop Freon-13 cryostat and the real time feedback made possible with the on-line processor.

Bibliography

This data was supplied by Dr. D. L. Coffeen and was abstracted from a paper "Airborne Infrared Polarimeter" by D. L. Coffeen, J. Hämeen-Anttila and R. H. Toubhans. This paper has been accepted for publication in Space Science Instrumentation, Volume 1, 1973.

SECTION 3 - QUICK-REACTION INTEGRATION CONCEPT

3.1 OVERVIEW

The integration concept as described in Section 3.0 of the Volume II Detailed Technical Report comprises hardware, software, and mission integration activities. Each of these activities is structured to efficiently respond to the user's requirements.

The integration of the experiment hardware requires that interface hardware be designed and fabricated. In some cases, the experiment will not have been designed specifically for the Sortie Lab, therefore, the "model shop" technique in fabricating the adapter hardware is proposed.

Integration of the experiment software, when required, will take advantage of the Launch Processing System (LPS) proposed for the overall Shuttle Program. The LPS will allow development and integration of the software to begin at the user's site, while the experiment hardware is being developed, so that software problems are minimized by the time the experiment hardware arrives at the QR integration site.

Mission integration is the task of integrating those mission oriented experiment requirements, such as Orbiter maneuvers, with the Shuttle mission planning functions. This entails providing the experiment requirement inputs to the Vehicle Management and Mission Planning System (VMMPS) presently being developed at MSC.

Each of these elements, the "model shop", the LPS and the VMMPS are described in this Appendix.

SECTION 3.2 KSC MODEL SHOP

One of the activities in integrating experiment hardware in the Quick-Reaction concept is the fabrication of interface adapter hareware. The installation of experiment hardware in the Sortie Lab on a one-time basis (R&D) requires that certain shop capabilities exist at the Quick-Reaction Integration location. These include the various facilities, equipment, and personnel skills associated with machine shops, electrical/electronic shops, woodworking shops, paint shops, etc. The typical output of these shops are those items of adapter hardware such as fluid and gas lines, electrical cables and harnesses, mounting fixtures, test aids, etc. that are required to provide for the satisfactory installation and operation of the experiment hardware. In the Quick-Reaction concept this is designated as the "model shop". This capability, or "model shop", exists at Kennedy Space Center in the Development Test Laboratory.

The Development Test Laboratory is part of the institutional base supporting all projects at the center. The capabilities of the laboratory are divided into four sections: The Electronics and Electrical Fabrication Lab, the Instrumentation Lab, the Test Lab and the Machine Shop. Included in the Test Lab is a class 100,000 clean room. Woodworking capabilities are combined with the Machine Shop. Twenty-eight technicians/craftsmen and supervisory personnel comprise the laboratory staff. Documentation requirements are minimal. Submittal of a Project Request Form, PSE 3488 NS, with the submitting NASA signature, is all that is required. Informal sketches of the project are included on this form. The capabilities of the Development Test Laboratory, e.g., all metal and machine work, plastics, wood, electrical wiring, tubing etc. appear to be well suited to the "model shop" concept proposed for the Quick-Reaction program.

3.3 LAUNCH PROCESSING SYSTEM

3.3.1 Functional Defintition

The LPS can be defined as a unified, institutional system which will provide for the rapid and efficient checkout, launch, and maintenance of the Space Shuttle, payloads, and other future space vehicles. The system will also provide for the operation and control of the utilities, logistics, and other ancillary functions attendant to the primary vehicle launch processing function.

The functional scope of the LPS can be defined in terms of the functional elements or "systems", as follows:

1. Vehicle Checkout and Launch System (VCLS)

   The VCLS provides for the ground command, control, monitoring, and data processing functions necessary to test, checkout and, launch the Shuttle vehicle. This system also provides for the above functions

C-2

3.3.1 Functional Definition (Cont.)

with respect to the GSE and Ground Support Systems (GSS) required in the test, checkout, and launch process.

2. Payload Checkout System (PCS)

The PCS provides for the ground command, control, monitoring, and data processing functions necessary to test, checkout, and launch payloads. This system also provides for the above functions with respect to the GSE and GSS required in the test, checkout, and launch process.

3. Vehicle Maintenance System (VMS)

The VMS provides for the ground command, control, monitoring, data processing, and analysis functions necessary to test, checkout and recertify Shuttle Line Replaceable Units (LRU) in the "bench" maintenance areas. This system also provides for the above functions with respect to the GSE and other special test equipment, as required.

4. Operations Support System (OSS)

The OSS provides for the command, control, monitoring, data processing and analysis functions necessary to test, checkout, and operate facility and ground support systems such as Shuttle ground landing aids, engine test stands, environmental chambers, etc.

5. Central Support System (CSS)

The CSS provides for the functions of data control, manipulation, storage, retrieval, processing, analysis, and other support as required by other elements of LPS. The CSS also provides for data transfer to and from other, remote data systems.

6. Management Support System (MSS)

The MSS provides for the functions of data collection, processing and analysis necessary to manage the launch center operations. The MSS provides for status monitoring, work scheduling, and implementation requirements for quality assurance, reliability monitoring, etc.

7. Logistics Support System (LSS)

The LSS provides for the data collection, monitoring, and control of materiel, supplies, and services required by the launch center.

8. Utilities Control System (UCS)

The UCS provides for the command, monitoring, and control of the utilities at the launch center. The utilities included are the Fire Protection and Alarm System; Electrical Power Distribution System; Water Booster Station and Distribution System; Waste Treatment Plants; Heating, Ventilating and Air Conditioning Systems; and the Heat Plants and Heat Distribution System.

The current concept of the LPS envisions a distributive data system as illustrated in Figure 2-3 The LPS will be composed of the hardware and software subsystems listed in Table 2-2.

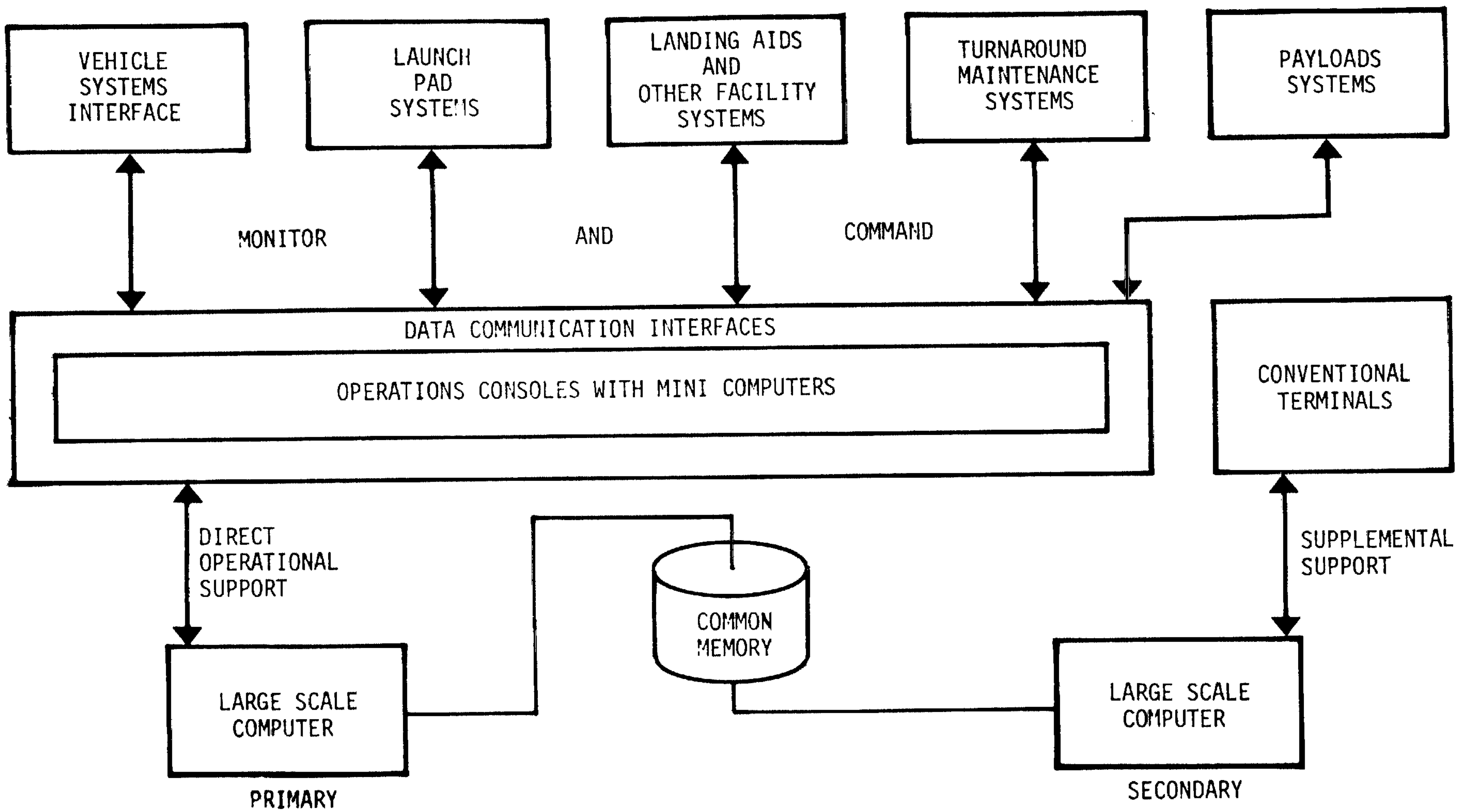

FIGURE 2-3 LAUNCH PROCESSING SYSTEM

	Subsystems	Description
HARDWARE SUBSYSTEMS	Instrumentation and Interface Subsystem	Consists of various sensors, signal conditioners, and other hardware units required to connect LPS to flight hardware and GSE and/or required to instrument GSE, Ground Support Systems (GSS), and Facility Systems.
	Communications Subsystem	Consists of the communications links (hardware, data bus, RF) switching equipment, and other hardware required to interconnect all LPS elements.
	Field Data Subsystem	Consists of processors, pre-processors, data storage units, and other data processing equipment required to perform the primary command, monitoring, and control functions (distributive concept).
	Central Data Subsystem	Consists of processors, pre-processors, mass storage units, and other data processing equipment required to perform the central support system functions (distributive concept).
	Displays and Controls Subsystem	Consists of the consoles, display units, general and special purpose command units (keyboards) required to provide the man/machine interface.
SOFTWARE SYSTEMS	Central Data System Software	Consists of the operating system, system test and diagnostic routines, higher order language compilers, integrated data storage and retrieval system, and other LPS global software.
	Field Data System Software	Consists of the operating system(s), test and diagnostic routines, display software, and other LPS Field Data System global software.
	User Software Subsystem	Consists of the test, checkout, monitoring, command, and other software required to test, operate, or control the flight hardware, GSE, GSS, or Facility Systems.

TABLE 2-2. LPS HARDWARE AND SOFTWARE SUBSYSTEMS

3.4 VEHICLE MANAGEMENT AND MISSION PLANNING SYSTEM

3.4.1 VMMPS Development at MSC

The advent of the Space Shuttle will impose a more complex mission management and mission planning environment than now exists. These result from the application of a reusable vehicle, an increase in the frequency of the flights, the Quick-Reaction requirement, the complexity of mission requirements, utilization of the Tug, and resource limitations as to availability of vehicles, facilities, and personnel. To meet the challenge of this operational environment:

- A Quick-Reaction mission planning capability must be developed.
- The mission planning cycle must be compressed to require fewer personnel.
- The mission planning capability must be able to quickly and effectively react to payload or mission changes.
- The planning software must include mechanisms for rapid and effective coordination, consultation, and conflict resolution, e.g., automated report generation, an effective information management system, and an extensive data base.
- The planning software must be designed to promote speed of computation, and to effectively make the proper accuracy versus speed compromise for the level of analysis and planning being performed.

Currently, the Mission Planning and Analysis Division (MPAD) of MSC is developing an on-line interactive software system, called the Vehicle Management and Mission Planning System (VMMPS). This system is aimed at providing support for the management and planning of Shuttle operations. The VMMPS is primarily intended to support the mission design and flight scheduling activities.

The development plan for the VMMPS calls for a phased development of the system. The first phase of the development is the development of a prototype software system. Thus, the VMMPS Phase IA consists of a set of existing programs used by the Mission Analysis Branch of MPAD. Phase IB is the initial version of the VMMPS which integrates the major subsystems of the VMMPS into an interactive software system. Phase IB is expected to be implemented in early April 1973. It will consist of:

- Flight Scheduling Subsystem (FSS)
- Information Management Subsystem (IMS)
- Mission Design and Analysis Subsystem (MDAS)

and the executive for these subsystems.

The Phase IB VMMPS will provide the capability to perform Space Shuttle studies concerning traffic modeling, fleet sizing, and operations cost analysis.

3.4.1 VMMPS Development at MSC (Cont.)

The Phase II VMMPS, which is currently being defined, will expand and augment the capability of the Phase I system to provide for detailed flight scheduling, mission planning, and Shuttle management support. A gross schematic representation of the Phase II VMMPS is shown in Figure 2-4. The functions of the major elements of the system are listed in Figure 2-5.

3.4.2 VMMPS Mission Planning Functions

The function of the Phase II VMMPS is to provide a concentrated, broad based, and flexible source of Shuttle mission planning related computational and data processing capability. The system must provide a rapid and efficient method for planning, designing, verifying, and documenting trajectory profiles corresponding to specified mission constraints and payloads. The complexity of the computational support required will, of course, depend on the phase of mission planning being executed. It is envisioned that the planning system will be able to support at least three levels of mission planning. These are:

Level 1 - Conceptual
Level 2 - Design
Level 3 - Operational Verification

As soon as mission objectives are specified, the conceptual phase (Level 1) is initiated using pre-established guidelines. The conceptual plan to satisfy the objective is developed within relatively few constraints. As a firmer idea of the plan of action evolves, analysis of the plan leads to the establishment of additional constraints. The termination of this phase is usually denoted by the establishment of a design mission plan or a series of alternative plans.

Using the design mission plan as a basis, analysts are able to establish detailed constraints of specifications as the first step in the (Level 2) design phase. These specifications are modified during development to produce a workable system that satisfies the objectives and provides the least penalty. When the system design is implemented and tested, further modifications of the plan are evolved to accommodate unforeseen restrictions or unanticipated capabilities. The design phase of mission development is usually terminated by the establishment of a reference mission plan.

From this point, development of the operational verification plan (Level 3) is started using all the known constraints. The interaction between planners and analysts continues until the optimum plan is defined. Optimum is defined as meeting

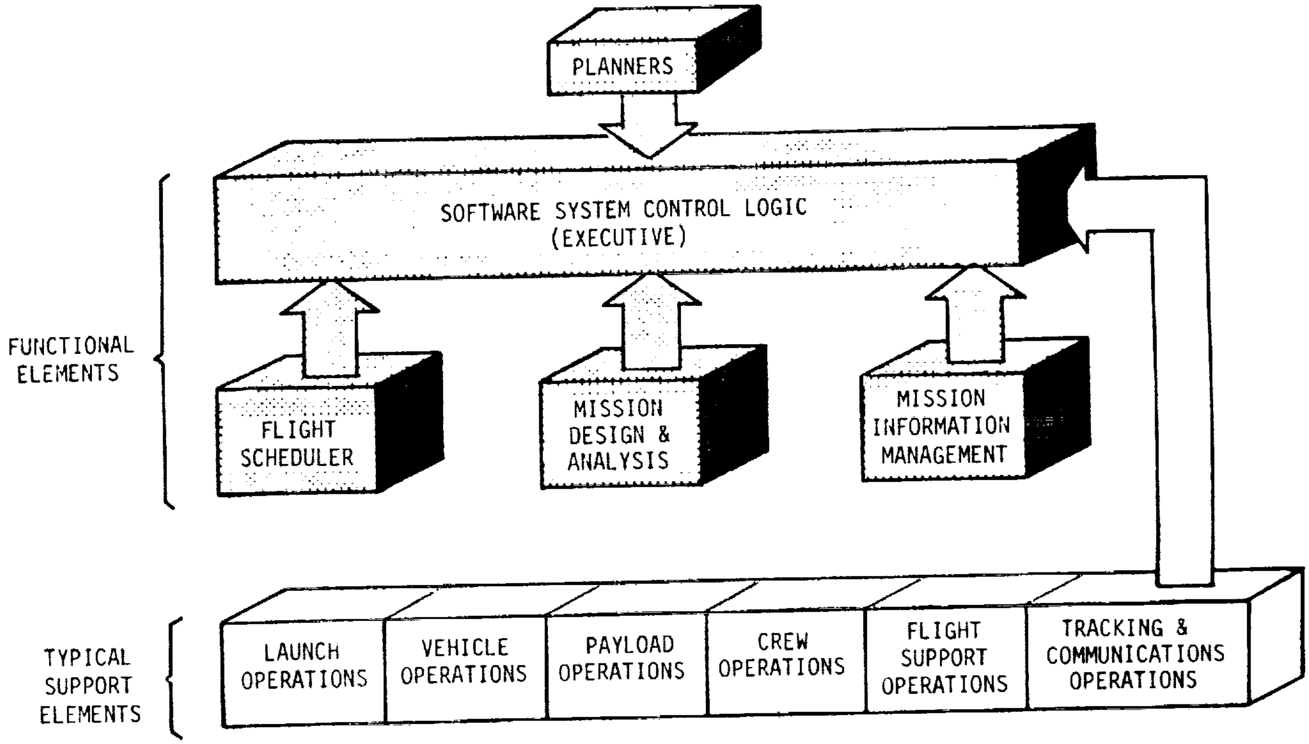

FIGURE 2-4 VEHICLE MANAGEMENT AND MISSION PLANNING SYSTEM

- FLIGHT SCHEDULER SUBSYSTEM
  - ASSIGN PAYLOADS
  - PROJECT ASSIGNMENT OF RESOURCES TO A MISSION
  - GENERATE LAUNCH SCHEDULES
- MISSION DESIGN AND ANALYSIS SUBSYSTEM
  - MISSION FEASIBILITY ANALYSIS
  - IDENTIFY TRAJECTORY/OPERATIONS CONFLICTS RESULTING FROM PAYLOAD GROUPING
  - ANALYZE CRITICAL, MARGINAL, OR UNIQUE MISSION PHASES
  - MANEUVER TARGETING ANALYSIS
  - GENERATE LAUNCH WINDOWS
  - PERFORMANCE EVALUATION
  - DEVELOP CONTINGENCY PLANS
  - DEVELOP MISSION PLANS (TRAJECTORY)
  - DEVELOP FLIGHT CREW AND SUPPORT TEAM TRAINING DATA
  - DEVELOP SPECIFIC MISSION SUPPORT DATA
- MISSION INFORMATION MANAGEMENT SUBSYSTEM
  - PROVIDE A CENTRALIZED INFORMATION SYSTEM FOR ALL ELEMENTS OF THE VMMPS
  - PROVIDE MANAGEMENT AND PLANNING INFORMATION RELATED TO SHUTTLE OPERATIONS STATUS AND MISSION PLANS
- VMMPS SUPPORTING ELEMENTS
  - PROVIDE OPERATIONAL STATUS DATA AND PROJECTIONS
  - PREDICT SYSTEM AND SUBSYSTEM PERFORMANCE
  - PROVIDE MODELS OF OPERATIONS REQUIRED FOR MISSION PLANNING AND FLIGHT SCHEDULING

FIGURE 2-5 VMMPS ELEMENT FUNCTIONS

3.4.2 VMMPS Mission Planning Functions (Cont.)

the mission with the minimum penalty due to constraint violations. Such constraints include not only the hardware, physiological, and operational constraints, but also the overall Shuttle program management constraints.

The VMMPS mission planning Level 1 software capability will: answer preliminary inquiries concerning the capabilities of the Shuttle system; generate candidate event sequences for a specific mission; and perform cursory evaluation of the specified missions from a trajectory and operations standpoint. This level of analysis should identify some of the more obviously desirable and undesirable features of each proposed Shuttle flight and provide the following type of answers:

YES: The Shuttle has the capability (time, ΔV, etc.) to fly a specified mission.

NO: The Shuttle does not have the capability to fly a particular mission as specified.

MAYBE: A more thorough analysis is required before an answer can be given.

Level 2 capability is used to perform the iterative refinement of the conceptual mission design to produce the preliminary reference mission. Level 3 capabilities are used to verify that the plan developed by the other two levels can be flown by the Shuttle, and that it satisfies the detailed mission objectives. It could also be used to verify the onboard and ground support software, develop realtime support data, generate crew and ground support team training data, and complete the mission time schedule.

Obviously, special provisions must be made to accomplish the mission planning role in the Quick-Reaction mode. This necessitates reducing the scope or eliminating the performance of one or more levels of mission planning activity and automating the remaining activities.

Some elements of the Level 2 and Level 3 capability are used to provide realtime support. The support provided, of course, depends on the particular mission requirements and the degree of autonomy achieved by the Shuttle itself.

The significance of the utilization of such a structured software system is that as the mission profile progresses toward a firmer definition, the accuracy of the simulation increases, thus providing an accurate final profile with a minimum cost of computer time.

3.4.3 VMMPS Development Approach

The approach taken for development of the VMMPS software capability is both phased and evolutionary. Experience shows that such an approach to the development of a complex software system is efficient because it:

- Allows the development to be flexible enough to respond to major requirement changes
- Reflects the on-going education of the developers and users
- Provides capability paced with need
- Minimizes the necessity for design decisions when little data is available
- Allows coordination with other agencies

The VMMPS development is amenable to a phased and evolutionary approach because of the phased hardware development and the increasing complexity of missions.

In line with this approach, the VMMPS development concentrates heavily on defining a mission planning concept which easily accepts new simulation capability as the system grows toward maturity. The near-term mission planning requirements and software definition is given more emphasis and is identified and treated in sufficient detail to be in proper perspective with the total required capability.

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SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS

Detailed Technical Report

Volume III

Appendix

SECTION 1 - INTRODUCTION

Phase 3 of the study covers the impact the Quick-Reaction Integration Concept has upon the launch site in terms of facilities, manpower and costs. The launch site is the baseline for the study.

An organization was developed to perform the functions described by the Work Breakdown Structure presented in Phase 2.

The concept, basically the organization, sensitivity to mission density was determined and an outline for a Quick-Reaction User's Guide was developed.

Finally, the performance of the Quick-Reaction Integration Concept was assessed for alternative locations. In addition, as an action item from the NASA Steering Group after the Phase 2 presentation, a limited survey of potential users was conducted to obtain a broader base of opinion of the Quick-Reaction Concept.

These tasks are presented in Volume III Detailed Technical Report. Further details and backup material is presented in this volume of the Appendix.

SECTION 2 - USER'S SURVEY

A limited survey of potential users was conducted to obtain a broader base of opinion of the Quick-Reaction concept. A list of those users responding and the results of the survey appear in Section 2.0 of the Volume III Technical Report. The following questionnaire was used for the survey.

INTRODUCTION

- TRW Study for KSC
- Quick-Reaction payloads a la CV-990
- Sortie Lab (MSFC)/Shuttle era
  - manned module
  - 7 day mission
  - multi-discipline
  - 2-4 experiment operators
  - attached to Orbiter
  - self-contained support subsystems
    ECLS, Power, DMS, Ports, Airlocks, Pallet, Thermal Control

PURPOSE OF STUDY

- Develop Operational QR Concept
- Characteristics: User Oriented, Short Time Spans, Low Costs, Min. Documentation, Simple to Integrate and Operate Experiments.
- Develop Hardware and Software Requirements
- Widen User Market

QUESTIONS

1. Would you want to participate in a program such as this?
2. If so, would you want to fly with your experiment?
3. If not possible, would you accept a trained flight operator to operate your experiment?
4. Given that you have an experiment on a QR Sortie and you are on the ground, would you generally require any real-time or near real-time data downlinked? Processed? On-board? Ground? Raw?
5. Would you require either C&W or C&D for your operator?
6. Would this generally require on-board processing?

7. If yes, which would you prefer to use:
    a. The SL DMS (furnished by SL)?
    b. Your own mini-computer (PI furnished)?
8. Would you prefer:
    a. Standard recorders (furnished)?
    b. Your own recorders (PI furnished)?
9. Would you need concurrent flight data, i.e., time, position, velocity, attitude, etc. in order to analyze your data?
10. Would you generally have mission requirements such as sun-angle limits, specific ground tracks, specific attitude or pointing requirements, altitudes, attitude holds, etc., i.e., anything that would require action by the Orbiter crew?
11. Any other comments?

SECTION 3 - QUICK-REACTION USER'S GUIDE

An outline of the Quick-Reaction User's Guide is presented in Section 3.0 of the Volume III Technical Report. A more detailed description of the contents of the User's Guide is presented here.

Quick-Reaction User's Guide

1.0 General Information

- 1.1 Shuttle Program Description
- 1.2 Quick-Reaction Sortie Mode Description
- 1.3 Orbiter/Sortie Lab Description
- 1.4 Sortie Lab Subsystems
- 1.5 Policies and Procedures
- 1.6 Management Organization
- 1.7 Documentation Requirements

This section is intended to familiarize the user with the overall Shuttle Program and, specifically, that portion related to the Quick-Reaction mode.

2.0 Facilities

- 2.1 User Laboratories - Describes in detail the laboratories, excluding support equipment, dedicated to bench level experiment checkout and calibration and other operations unique to the experiment.
- 2.2 Integration Test Stand - Describes the facility where experiment installation and checkout in the Sortie Lab is performed.
- 2.3 Support Facilities - Describes facilities, other than the user's laboratories and integrated test stand, that are available to the user, such as model shop, photo labs, data center, etc.
- 2.4 Support Equipment - Describes the support equipment such as meters, power supplies, etc. available to the user.

3.0 Schedules

- 3.1 Primary Operations Flow - Describes the normal sequence of events from experiment arrival at the integration site through postlanding operations.
- 3.2 Integration Timeline - Describes the specific operations which must be performed, along with the time spans, for integrating experiments into the Sortie Lab.
- 3.3 Contingency Operations - Describes the alternate plans to effect the turnaround of malfunctioned experiment hardware in order to maintain Orbiter flight schedule.

4.0 Safety Specifications

4.1 Mandatory Specifications - Describes those safety specifications to which experiment hardware must comply in order to be flight worthy.

4.2 Discretionary Specifications - Describes those safety specifications to which compliance is at the discretion of the user. These specifications affect successful experiment operation as opposed to vehicle safety.

5.0 Space Flight Qualification Requirements

5.1 Thermal/Vacuum Tests - Delineates the level of tests required for flight hardware if the hardware was not previously been qualified for space flight. Includes list of commercial facilities qualified to perform these tests.

5.2 Vibration Tests - Same as Paragraph 5.1 above.

6.0 Integration Requirements

6.1 Hardware - Describes the concept for adapting experiment hardware to the Sortie Lab, the design and fabrication of interface adapter hardware.

6.2 Software - Describes the technique for developing experiment software to be compatible with the Sortie Lab Data Management System, the utilization of launch processing system consoles at the user's facility.

6.3 Mission - Describes typical user's mission requirements such as Orbiter attitude changes, attitude hold, etc. and how these requirements interface with Shuttle mission planning.

7.0 Experiment to Sortie Lab Interface

7.1 Mechanical - Describes the various mounting hardware and locations, i.e., racks, ports, longerons, etc., as well as gas and fluid line connections.

7.2 Electrical - Describes the electrical interfaces such as power and data management system, included are EMI specifications, impedance, data rates, etc.

8.0 Experiment Design References

8.1 Qualified Materials - As an aid to the user for experiment hardware development, a list of reference documentation delineating qualified materials will be included in the guide.

8.2 Standard Design Practices for Space Flight Hardware - Same as paragraph 8.1 above.

9.0 Range Support and Requirements

At the present time range support pertains to launch vehicles, not payloads as we define them for this study. The section is included here in anticipation that during the Shuttle era there may be some range support functions to aid the user. Range requirements with respect to experiments would essentially be covered by Section 4.0 Safety Specifications.

10.0 Launch Operations and Procedures

Describes on-pad activities, countdown, etc. during shuttle launch operations and the procedures detailing these operations. This covers final experiment operational checks.

11.0 Flight Operations

Describes on-orbit operations and capabilities, the interfaces between experiment and Orbiter operations, experiment flight operator procedures (if user doesn't fly with his instrument) and data transmittal via telemetry and/or voice communication.

12.0 Postflight Operations

Describes postlanding operations, the removal of the time critical data and experiments at the Orbiter safing area, the normal off loading of experiments at the integration area, data processing and data distribution.

13.0 Proposals

This section is to aid the prospective user in generating a proposal plan for his scientific investigation. It describes the procedure and contents of the proposal and lists candidate agencies or commercial firms to which the proposal may be submitted for funding.

14.0 Financial and Legal Aspects

Details of this section are not yet available but the section is included in the guide to familiarize the user with these important requirements.

15.0 Experiment Requirements Transmittal Form

The Experiment Requirements Transmittal form is provided to allow the user to efficiently communicate preliminary experiment requirements to the integration site. This establishes initial contact with the mission manager, the user's single point contact, and also initiates advanced integration site preparations for the user. This section describes how the form should be completed by the user.

SECTION 4 - LAUNCH SITE IMPACT

4.1 QR SORTIE LAB ASSEMBLY, TEST, AND CHECKOUT AREA

Locating the QRSL work area in the MSOB creates the least impact on the launch site because the modifications necessary are minimal. A support stand for the QRSL is required. It is located on the high bay floor at the west end of the building. Work stands are provided to surround the QRSL when mounted in the support stand. In addition, there must be sufficient room around the work stands to provide for adequate traffic flow. The sketch below (Figure 3-1) provides a means to visualize the 10,000 SF space requirements. Also, see Page 4-7 of Volume III, Detailed Technical Report. The modifications necessary to install the support and work stands are relatively minor. Rerouting of electrical power, gases, etc. from the GSE trench on the north side of the high bay is also minor in nature. It is assumed

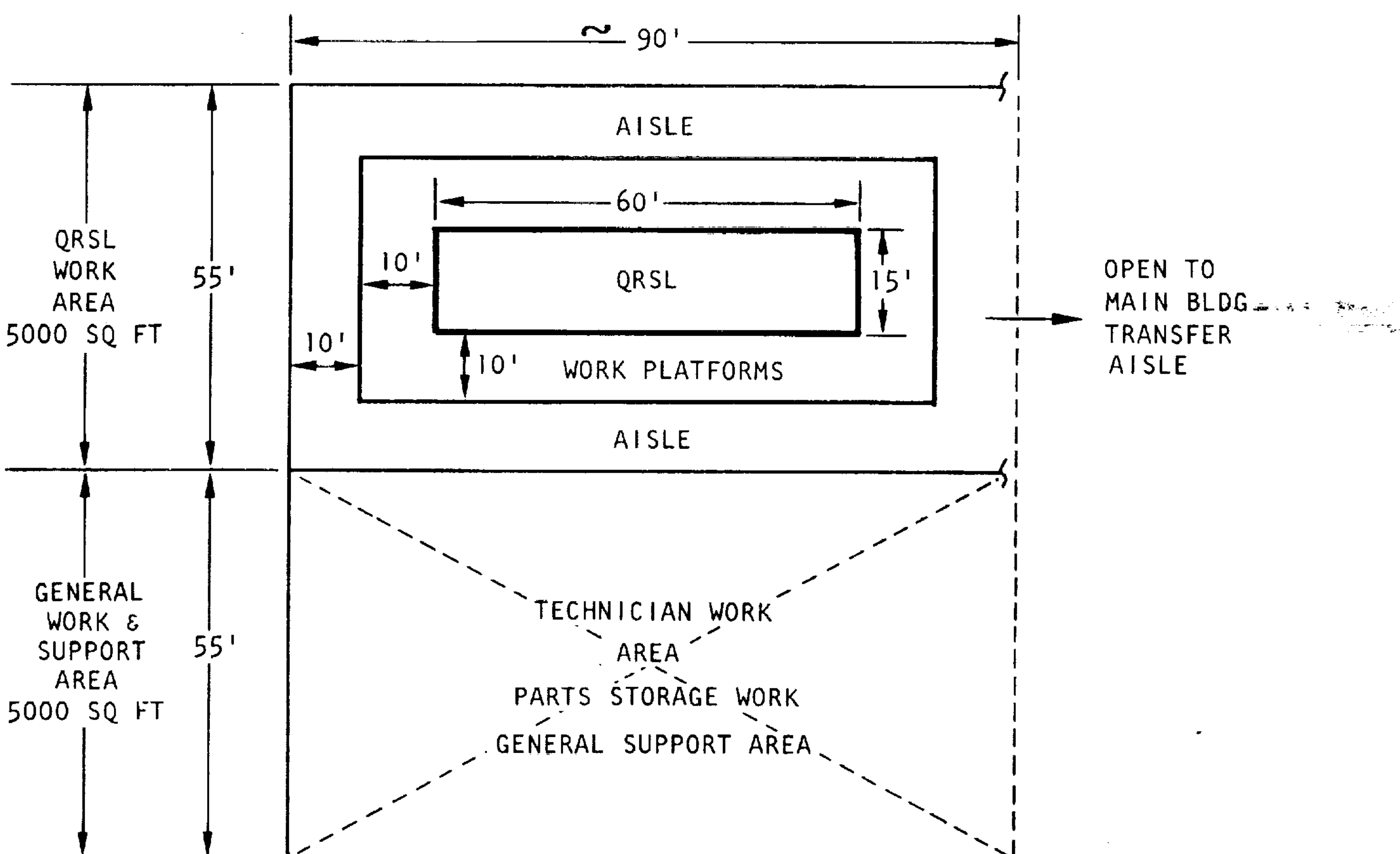


FIGURE 3-1. QRSL ASSEMBLY, TEST, AND CHECKOUT AREA

that the capabilities of these commodities available for use are adequate. The QRSL ground systems needed for checkout at this location can be located under the work stands, in the adjacent support area, in the GSE trench or outside the building on the south side with piping or cables routed through the GSE trenches to the work stand.

A general support area is shown adjacent to the QRSL work area. This contains the work benches, spare materials, parts storage, and a general technician work area.

Twenty-five ton overhead cranes are already in the building and can be utilized for lifting and moving the QRSL. They have a working hook height capability of 50 feet.

It is estimated that $250,000 will cover the mods necessary to accommodate the QRSL work area in the MSOB. This does not include the stands nor any of the GSE. These items are discussed later. This dollar figure was developed by multiplying $100,000 estimated for labor and materials by a factor of 2 1/2. The factor represents necessary contractual charges above the labor and materials costs for such items as profit, overhead, insurance, taxes, bonds, general supervision, etc.

4.2 EXPERIMENT LABORATORY AREA

The PI local lab areas are shown in the Volume III Detailed Technical Report as being located in the MSOB laboratory area near the QRSL work area (Page 4-7). Modifications are required to provide these local PI labs but they are relatively minor. Partitions must be moved or provided to divide the existing space into the areas for the different experiment groups. Airlocks are required at the entrances of the labs to assist in maintaining the class 100,000 cleanliness. The walls, ceilings, and the floors require treatment to help maintain the clean atmosphere. The existing heating and air conditioning system is capable of maintaining the temperature and humidity requirements. Duct modifications may be necessary to add high filtration filters in the lab air outlets. The sizes of the labs are estimated as follows:

Group A experimenters	- 2000 SF
B	- 1300
C	- 600
D	- 1000
E	- 600
F	- 2000
TOTAL	- 7500 SF

4.2 EXPERIMENT LABORATORY AREA (Cont.)

Since the area for the labs already exists and relatively minor modifications are required it is estimated that $20 per square foot will cover the labor and materials. In addition, there is a possibility of utilizing an existing 1000 SF biological lab. Assuming this is the case, it leaves 6500 SF to modify. At $20/SF the cost is $130,000 multiplied by the factor of 2 1/2 again. The estimated cost of these mods is then $325,000.

4.3 ENVIRONMENTAL QUALIFICATION LAB

In the event experiment hardware arrives at the QRI activity at the launch site that has not been flight certified, the capability must exist to perform this service. It is estimated that a facility with 2000 SF is required for these tests. No search was made during this study to find a suitable unused facility although it is probable one could be found that could be modified. Instead, the cost estimate shown is for a new facility that contains the features usually found in this type of facility. It is estimated that this facility will cost about $75 per square foot complete including the markup factor but excluding the test equipment. The construction cost for this facility is then $150,000.

4.4 SUMMARY OF FACILITY REQUIREMENTS

Table 3-1 provides a general summary of the information above. The total estimated cost of the Facility Requirements is $725,000.

4.5 GROUND SUPPORT EQUIPMENT REQUIREMENTS

Numerous items of equipment are required to outfit the facilities for the Quick-Reaction Integration activities at the launch site. An estimate of these ground support equipment requirements and their estimated costs are shown in Table 3-2. This table summarizes the requirements for the checkout and test equipment needed to equip the laboratories for the various groups of experiments, the test and support systems for the QRSL and the equipment needed to outfit the Environmental Qualification Lab.

4.5 GROUND SUPPORT EQUIPMENT REQUIREMENTS (Cont.)

In the area of the PI's local laboratory, it is assumed that the expensive, one-of-a-kind test equipment for the various experiments will be brought to the launch site from the home lab by the PI. The costs shown in Table 3-2 are for typical and ordinary lab support equipment usually found in labs of this kind.

The costs of GSE and support systems for the QRSL assumes that the SL and the ground systems are operational and there are not more R&D cost charge-offs. These costs reflect simply ordering a duplicate of systems and equipment that already exists.

QR FACILITY REQUIREMENTS	KSC CAPABILITY OR SPACE AVAILABLE YES	NO	KSC IMPACT	ESTIMATED COST OF IMPACT (IN 1973 DOLLARS)
1. QRSL - Assy, Test & C/O Area: 10,000 SF			GENERAL: Minor mods required to reroute and relocate some items, e.g., water, air, GN_2 lines, electrical outlets, etc.	$250,000
• Work & Test Stand Area - 5000 SF	X			
• Technician Work Area, Parts Storage, General Support - 5000 SF	X			
• Overhead Crane: 20 tons; 35' hook height	X			
• Class 100,000 clean	X			
• Gaseous N_2, H_2, O_2, He	X			
• Shop Air	X			
• Electric Power (AC & DC)	X			
• Grounding	X			
• Water	X			
• Lighting	X			
• Vacuum	X			
• Drains	X			
2. Experiments				$325,000
• Lab Areas				
Group A - 2000 SF	X		MODIFY EXISTING AREA TO LAB CONFIGURATION - 6500 SF	
B - 1300	X			
C - 600	X			
D - 1000	X			
E - 600	X		NOTE: A 1000 SF Bio-lab presently exists at KSC and could be used.	
F - 2000	X			
7500 SF TOTAL FOR LABS				
3. Environmental Qualification Lab 2000 SF required	None identified		New construction	$150,000
			ESTIMATED FACILITY COST	$725,000

TABLE 3-1. ESTIMATED COSTS OF FACILITY REQUIREMENTS

EXPERIMENT CHECKOUT AND TEST SUPPORT EQUIPMENT	
GROUP A:	
Power Supplies	$ 2,000
Photo Lab	25,000
Optics Bench and Equipment	15,000
IF Test Connection Unit	8,000
Special Tools	2,000
LPS Equipment	5,000
Miscellaneous	5,000
Subtotal	$ 65,000
GROUP B:	
Same as Group A except no optics required	
Subtotal	$ 45,000
GROUP C:	
Power Supplies	$ 5,000
Screen Room	15,000
Test Boxes	10,000
LPS Equipment	5,000
Miscellaneous	5,000
Subtotal	$ 40,000
GROUP D:	
Power Supplies	$ 5,000
Test Boxes	8,000
Anechoic Chamber	25,000
LPS Equipment	5,000
Miscellaneous	2,000
Subtotal	$ 45,000
GROUP E:	
General Purpose Equipment	$ 15,000
LPS EQuipment	5,000
Subtotal	$ 20,000
GROUP F:	
Biological Lab Equipment	$ 30,000
LPS Equipment	5,000
Subtotal	$ 35,000

SUMMARY:	Group			
	Group A -	$65,000		
	B -	45,000		
	C -	40,000	TOTAL	$250,000
	D -	45,000		
	E -	20,000		
	F -	35,000		

Note: All cost estimates are in 1973 dollars.

TABLE 3-2. ESTIMATED COSTS OF GSE REQUIREMENTS

QUICK-REACTION SORTIE LAB GROUND SUPPORT EQUIPMENT		
QRSL GROUND SYSTEMS		
Ground Electrical Power		$ 75,000
Gases		50,000
ECLS		100,000
Handling & Accessory Equipment		
QRSL Support Stand	$25,000	
Work Platforms	75,000	
Transporter	25,000	
Slings & Fixtures	10,000	
		135,000
Communications		10,000
LPS Equipment		50,000
Miscellaneous		30,000
TOTAL		$450,000

LPS EQUIPMENT	
LPS Terminals, Computers, Peripherals, etc.	$150,000
LPS Installation, Cables, Miscellaneous	50,000
TOTAL	$200,000

ENVIRONMENTAL QUALIFICATION LAB EQUIPMENT	
Shaker Tables, Controls, Installation, etc.	$100,000
Thermal-vacuum Chamber, Controls, Install, etc.	300,000
General Lab Equipment and Miscellaneous	100,000
TOTAL	$500,000

Note: All cost estimates are in 1973 dollars.

TABLE 3-2. ESTIMATED COSTS OF GSE REQUIREMENTS (Cont.)

SECTION 5 - ORGANIZATION AND MANPOWER ANALYSIS

The Quick-Reaction Sortie Lab (QRSL) used as the baseline for this study is basically a standard Sortie Lab including the subsystems. To determine the QRSL manpower requirements it is first necessary to know the manpower requirements for the standard Sortie Lab and the assumptions that were made in establishing these figures. The following information was obtained from Jack H. Dickenson, KSC, LS-TEC, the KSC Sortie Lab representative. These numbers are rough estimates prepared by NASA and the manpower loading has not been worked in any depth as yet. In the process of establishing these figures, several assumptions were made. These were:

- Two shift operations
- SL is fully checked out and integrated (experiments and SL when it arrives at KSC
- Six weeks is required for first SL from arrival through launch
- SL refurbishment requires two weeks
- Refurbishment consists of operations such as: R&R time critical components, review flight and test data for anomalies, SL subsystems tests, install new experiment module, etc.
- Four Sortie Lab flights in first year
- Manpower for NASA Quality Control (QC), supervision, safety, Test Conductor (TC's), etc. assumed to be part of institutional base and not included here.

Based on this information the standard SL manpower requirement and the composition is shown in Table 3-3 below.

SL SUBSYSTEMS	KSC ENGRS	CONTRACTOR ENGRS	TECHS	
ECLSS	2	4	2	
ELECTRIC POWER	2	4	1	
COMM/ INSTR	2	4	1	
STRUCT/MECH/ORD	1	2	2	
CONTROL/DISPLAY	1	2	1	
GSE	2	4	2	
EXPERIMENTS	3	6	1	
TOTAL	13	26	10	= 49

TABLE 3-3. STANDARD SORTIE LAB MANPOWER ESTIMATE

Organization and Manpower Analysis (Cont.)

For the purposes of this study, an additional 50% was added to account for normal administrative functions usually required to support the technical personnel. This factor adds 7 people (rounded off) to the KSC Engineer category, 13 to the Contractor Engineers, and 5 to the Technicians. Totalling all of these yields 74 personnel required as the permanent Sortie Lab crew at KSC to service and operate previously integrated vehicles.

The QRSL operations baseline is considerably different in that all of the integration activity is to be performed at the launch site. Volume III of the Detailed Technical Report, Section 5.0, shows a Work Breakdown Structure (WBS) that identifies the QR functions that must be performed and two approaches to QRIA organizations to perform them. Both organizational approaches are elements of the Shuttle Operator's organization. Table 3-4 of this Appendix, shows the matrix used to perform the manning analysis for the completely independent and autonomous QRIA organization which includes its own QRSL O&M team. Table 3-5 further indicates the analysis used to determine the number of technicians needed for the QRSL M&O activities.

The abbreviated organization shown in the Volume III Detailed Technical Report, Page 5-11, indicates a need for less QRIA people because of a greater reliance on support from the parent organization, the Shuttle Operator, in the areas of Planning and Control, Engineering, and the existing SL M&O team at KSC. This approach relies on a more efficient use of existing organizations and supplementing them with additional personnel to handle the additional four QR flights a year. The smaller number of people required for this organization was determined by reducing those identified in the autonomous organization in the areas mentioned above. The supplemental personnel for the additional QRSL payloads were determined by adding to the technician, shop management, and subsystems engineering activities of the KSC permanent SL team. Table 3-6 shows a summary of this analysis.

QRIA AUTONOMOUS ORGANIZATION

MANPOWER REQUIREMENTS DEVELOPMENT MATRIX

	MANAGER	SUPERVISOR	ASSIST. SUPERVISOR	GENERAL FOREMAN	FOREMAN	ASSIST. FOREMAN	ADMINISTRATOR	SECRETARY	PLANNER/SCHEDULER	CLERK/CLERICAL	ENGINEER/SCIENTIST	ENGINEERING AIDE	DRAFTSMAN	CONFIGURATION CONTROL	MECHANICAL TECH.	ELECTRICAL TECH.	INSTRUMENTATION TECH.	CRAFTSMAN/ARTISAN	PRODUCTION CONTROL	PROGRAMMER	LOGISTICS	TYPIST	WRITER/EDITOR	LIBRARIAN	DATA ANALYST	TOTAL 191
OPERATIONS MANAGER	1		1					1																		3
MISSION MANAGER	4																									4
SORTIE LAB OPERATIONS	1							1																		70
QRSL OPERATIONS AND MAINTENANCE SUPPORT		1		1	2	4	1		2	4									2							
- GROUND SYSTEMS															9	10	2									
- VEHICLE SYSTEMS															8	5	2									
SUBSYSTEM ENGINEERING		1																								
- MECHANICAL											3															
- ELECTRICAL											3															
- INSTRUMENTATION											2															
SL DATA ANALYSIS		1																							5	
ENGINEERING	1							1																		28
INTEGRATION AND ANALYSIS		1	1					1				4														
- THERMAL											1															
- OPTICS											1															
- PHOTO											1															
- RF											1															
- DYNAMICS											1															
- MECHANICAL											1															
- ELECTRICAL											1															
- INSTRUMENTATION											1															
DESIGN ENGINEERING		1											4													
- MECHANICAL											1															
- ELECTRICAL											1															
- STRUCTURAL											1															
- INSTRUMENTATION											1															
ENGINEERING LIAISON											2															
EXPERIMENT OPERATIONS	1							1																		18
EXPERIMENT OPERATIONS SUPPORT		1					2											5	2							
DATA REDUCTION & DISTRIBUTION		1					1	1				3														
SOFTWARE OPERATIONS	1							1																		13
SORTIE LAB DMS		1								1										4						
EXPERIMENT SOFTWARE										1										2						
SHUTTLE/SID DMS LIAISON											2															
MISSION SUPPORT	1							1																		12
MISSION REQUIREMENTS											3	2														
EXPT OPS PROCEDURES & FAMILIARIZATION										1												1	3			
PLANNING AND CONTROL	1		1					1		1																43
OPERATIONS SCHEDULING		1							4	2																
CONFIGURATION MANAGEMENT		1								2				2												
PRODUCTION CONTROL & LOGISTICS		1								2									2		2					
TECHNICAL PUBLICATIONS			1																			4	4	2		
ADMINISTRATIVE CONTROL		1					4	1	3																	

MANPOWER REQUIREMENTS DEVELOPMENT MATRIX FOR QRIA AUTONOMOUS ORGANIZATION

TABLE 3-4

FIGURE 3-4 QRIA AUTONOMOUS ORGANIZATION MANPOWER

TECHNICIANS FOR QRSL							
VEHICLE SUBSYSTEMS				GROUND SUBSYSTEMS			
	MECH	ELECT	INST		MECH	ELECT	INST
FUEL CELLS	2	1		FUEL CELL CRYOS	2	2	
HP GAS	2	2		GND ELECTRICAL		4	
DATA MGMT/INSTRUMENTATION			2	HP GAS	2	1	
ECLS	2	1		LPS/DMS			2
STRUCTURES/ORDNANCE	2			ECLS	2	1	
ELECTRICAL/CONTROL & DISPLAY		3		STRUCTURES	1		
				ESE (CONTROL & DISPLAY)		2	
				MECHANICAL/STRUCTURAL	2		
	8	5	2		9	10	2
TOTALS (TECHNICIANS)	15 VEHICLE				21 GROUND		

TABLE 3-5 TECHNICIANS FOR QRSL

1. ENGINEERING TOTAL 21

a. Management - 2

b. Integration and Analysis Engineering - 13

1 supervisor + 1 assistant supervisor
11 engineers/scientists/aides/draftsmen

1 thermal	1 dynamic	1 structural
1 photo	1 mechanical	1 secretary
1 optical	1 electrical	1 engineering aide
1 RF	1 instrumentation	

c. Design Engineering - 4

1 supervisor	1 electrical
1 mechanical	1 instrumentation

d. Engineering Liaison - 2

2 engineers/scientists

2. EXPERIMENT OPERATIONS TOTAL 18

a. Management - 2

b. Experiment Operations Support - 10
(Artisan Group)

1 supervisor	2 administrative
5 craftsmen	2 production control

c. Data Reduction and Distribution - 6

1 supervisor	1 administrative
1 secretary	3 engineering aides

3. SOFTWARE OPERATIONS TOTAL 13

a. Management - 2

b. Sortie Lab DMS - 6

1 supervisor
1 secretary
4 programmers

c. Experiment Software - 3

1 clerk
2 programmers

d. Shuttle/SID/DMS Liaison - 2

2 engineers/scientists

TABLE 3-6. MANPOWER ANALYSIS - ABBREVIATED ORGANIZATION
(Utilizes Existing SL Operating & Maintenance Crew for Standard Subsystem on QRSL)

4. MISSION SUPPORT — TOTAL 12

   a. Management - 2

   b. Mission Requirements - 5

      1 supervisor
      1 secretary
      3 analysts

   c. Flight Procedures - 5

      1 supervisor
      1 typist
      3 engineers/writers

5. PLANNING AND CONTROL GROUP — TOTAL 16

   a. Management - 2

   b. Operations Scheduling - 7

      1 supervisor
      4 schedulers
      2 clerks

   c. Production Control and Logistics - 7

      1 supervisor   2 production control
      2 clerks   2 logistics

6. OPERATIONS MANAGER — TOTAL 3

   a. Management - 3

      1 general manager
      1 assistant manager
      1 secretary

7. MISSION MANAGERS — TOTAL 4

8. ABBREVIATED ORGANIZATION MANPOWER REQUIREMENT - 87

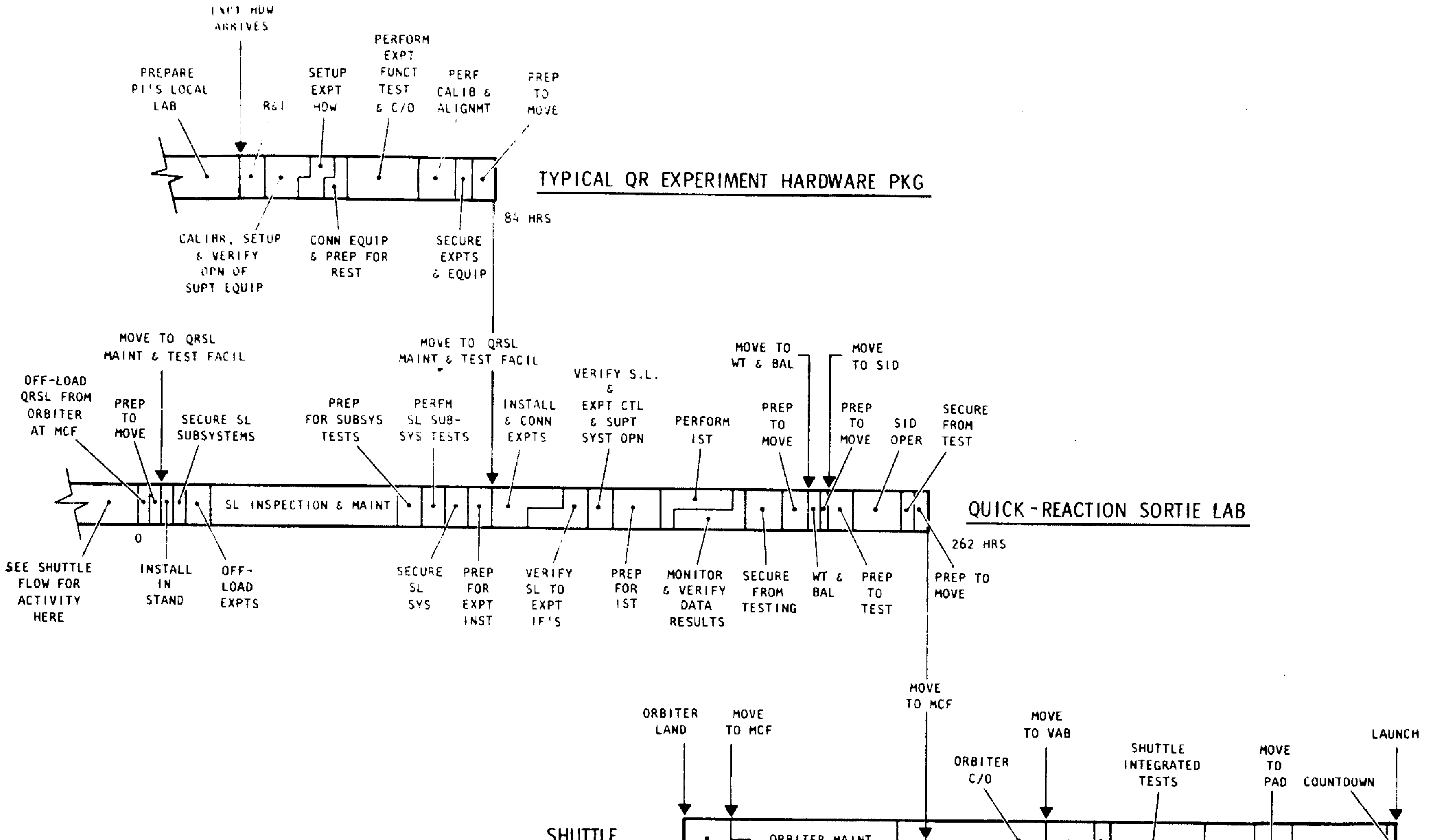
9. PLUS 26 TO SUPPLEMENT EXISTING STANDARD SORTIE LAB CREW.

10. GRAND TOTAL = 113

TABLE 3-6. MANPOWER ANALYSIS - ABBREVIATED ORGANIZATION (Cont.)
(Utilizes Existing SL Operating & Maintenance Crew for Standard Subsystem on QRSL)

SECTION 6 - SENSITIVITY ANALYSIS

The time-based functional flow diagram shown in Figure 3-2 was developed to show the time phased ground operations relationship between the experiments, the QRSL, and the Shuttle. This flow diagram was used as the basis for developing the sensitivity analysis figure shown on Page 7-5 of Volume III Detailed Technical Report. The figure shown on Page 7-7 of Volume III is simply a highly condensed version of Figure 3-2 used for presentation purposes. The Shuttle flow is based on the KSC Shuttle Program waterfall chart dated 4 May 1972. The QRSL flow is based on an undated flow diagram for the standard SL. The ground operations were modified to accommodate the QR activities. The flow for the experiments represents TRW's analysis of activities generally associated with experiments of the kind being flown in the QR Program.



NOTE:

1. FOR BASELINE THE EXPERIMENTS AND QRSL ACTIVITIES ARE SINGLE SHIFT, THE SHUTTLE IS 2 SHIFT.

FIGURE 3-2. QRIA TIME-BASED FUNCTIONAL FLOW DIAGRAM

SECTION 7 - LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS

The location/responsibility alternatives analysis was represented in Section 8.0 of the Volume III Detailed Technical Report. The analysis replaced the Site Trade Study per direction of the NASA Steering Group following the Phase 2 Program Review.

The parameters and alternatives used in the analysis were developed in Phase 2 and were reviewed by the Steering Group. The analysis then compared the alternatives against the approved parameters. Figure 3-3 represents a summary of the analysis depicting the rationale for each parameter with respect to each alternate location.

LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS

SUMMARY SHEET

EVALUATION PARAMETERS	BASELINE - SINGLE LOCATION/ORG.	ALTERNATE A — TWO LOCATIONS, TWO ORGANIZATIONS	ALTERNATE A1 — n LOCATIONS, n ORGANIZATIONS	ALTERNATE B — ONE LOCATION, TWO ORGANIZATIONS
MEETS USER DESIRES, REQUIREMENTS, CONSTRAINTS	SINGLE LOCATION FOR INTEGRATION, PRELAUNCH, POST FLIGHT ACTIVITIES, OTHER USER DESIRES MET. SINGLE ORGANIZATION PROMOTES INFORMAL PROCEDURES, MINIMUM PAPERWORK	USER MAY HAVE TO SET UP AT 2 LOCATIONS SEQUENTIALLY. MORE FORMAL PROCEDURES, PAPERWORK DUE TO TRANSFER OF RESPONSIBILITY BETWEEN ORGANIZATIONS. OTHER USER DESIRES MET	TO INDIVIDUAL USERS, SAME AS FOR ALTERNATE A.	SAME ADVANTAGES AS BASELINE FOR SINGLE LOCATION. INCREASED FORMALITY, PAPERWORK DUE TO 2 ORGANIZATIONS. OTHER USER DESIRES MET.
IS COMPATIBLE WITH ON-GOING PROGRAMS	USES SORTIE LAB SUPPORT TEAM AT LAUNCH SITE FOR M & O. USES SHUTTLE PROGRAM MANAGEMENT SYSTEMS AND FIELD MAINTENANCE SHOPS	UNABLE TO EVALUATE - POTENTIAL FOR USING ENGINEERING AND DEVELOPMENT RESOURCES AT A DEVELOPMENT CENTER.	UNABLE TO EVALUATE - SAME AS ALTERNATE A.	SAME AS BASELINE, BUT SOME INCREASE IN MANPOWER, FORMAL PROCEDURES DUE TO ORGANIZATIONAL INTERFACE.
MINIMUM PAYLOAD PROCESSING TIME	MINIMUM PROCESSING TIME - NO SHIPPING AND RECEIVING, SPARES AVAILABLE ON-SITE. MIN PAPERWORK DUE TO SINGLE ORGANIZATION.	ADD SHIPPING TIME FOR SORTIE LAB, GSE AND SPARES, "ACTIVATION" TIME AT LAUNCH SITE AFTER ARRIVAL. SPARES PIPELINES EXTENDED.	SAME AS ALTERNATE A.	MINIMUM PROCESSING TIME RELATED TO CO-LOCATION FACTORS. SLIGHT INCREASE DUE TO ORGANIZATIONAL INTERFACES - MORE FORMAL PROCEDURES, PAPERWORK.
MINIMUM CONTINGENCY RECYCLE TIME	MINIMUM RECYCLE TIME - REPAIR CAPABILITY AND EXPERIMENT INTEGRATION SKILLS AND EQUIPMENT AVAILABLE LOCALLY.	SEVERE RECYCLE PROBLEM IF SORTIE LAB OR EXPERIMENTS REQUIRE LEVEL II MAINTENANCE, SHIPPING AND RECEIVING, AIRCRAFT SCHEDULING, INDUCE DELAYS.	SAME AS ALTERNATE A.	SAME AS BASELINE
MINIMUM ORBITER SCHEDULE IMPACT RISK	MINIMUM RISK - SHUTTLE AND ORI ACTIVITY UNDER SAME MANAGEMENT, COMMON SCHEDULING ACTIVITY, CO-LOCATED REPAIR CAPABILITY.	MAXIMUM - GEOGRAPHICAL SEPERATION INTRODUCES SHIPPING TIME, DELAYS, CONTINGENCY RECYCLE TIME HIGH. LOGISTICS MORE COMPLEX. SEPERATE MANAGEMENT/SCHEDULING ACTIVITIES	SAME AS ALTERNATE A	RATES SLIGHTLY BELOW BASELINE, DUE TO ORGANIZATIONAL INTERFACES, SEPERATE SHUTTLE AND SORTIE LAB SCHEDULING ACTIVITIES
MOST EFFECTIVE EQUIPMENT/ FACILITY USE	NO DUPLICATION DUE TO SINGLE LOCATION.	SOME DUPLICATION; EXPERIMENT LABS AT LAUNCH SITE, SORTIE LAB M & O FACILITY AT BOTH SITES, POSSIBLE REQUIREMENT FOR SID AT REMOTE SITE.	DUPLICATION NOTED FOR ALTERNATE A IS MULTIPLIED BY n FOR ALTERNATE A1	SAME AS BASELINE
MOST EFFECTIVE MANPOWER/ SKILLS USE	MOST EFFECTIVE, DUE TO SINGLE ORGANIZATION, LOCATION, USE OF MANPOWER FROM ON-GOING PROGRAMS.	UNABLE TO EVALUATE - CANNOT DETERMINE POTENTIAL USE OF PERSONNEL FROM ON-GOING PROGRAMS AND/OR INSTITUTIONAL BASE AT REMOTE SITE	SAME AS ALTERNATE A	SLIGHT INCREASE IN MANPOWER OVER BASELINE DUE TO ORGANIZATIONAL INTERFACES - ADDED ADVISORS, LIAISON, ETC.
MINIMUM DOCUMENTATION	MINIMUM DOCUMENTATION: CO-LOCATION REDUCES COMMUNICATIONS PAPER; SAME ORGANIZATION REDUCES ACCOUNTABILITY PAPER.	TWO LOCATIONS CAUSES MORE FORMALITY IN COMMUNICATIONS - REQUIREMENTS, STATUS REPORTS, DIRECTIVES, ETC. SEPERATE ORGANIZATION INCREASES ACCOUNTABILITY PAPER	ADDED DOCUMENTATION REQUIREMENTS OF ALTERNATE A ARE MULTIPLIED BY n.	SOME WHAT ABOVE BASELINE DUE TO MORE FORMAL COMMUNICATIONS/ ACCOUNTABILITY DUE TO ORGANIZATIONAL INTERFACE.
MINIMUM TRANSPORTATION COST/TIME	MINIMUM - CO-LOCATION PRECLUDES ALL SHIPMENT OF SORTIE LAB AND SPARES, EXCEPT FOR LEVEL III MAINTENANCE.	MAXIMUM - SHIPMENT OF SORTIE LAB, GSE, AND PERSONNEL FROM REMOTE SITE TO LAUNCH SITE AND RETURN. POSSIBLE CONTINGENCY RECYCLE.	SAME AS ALTERNATE A	SAME AS BASELINE

FIGURE 3-3 LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS

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